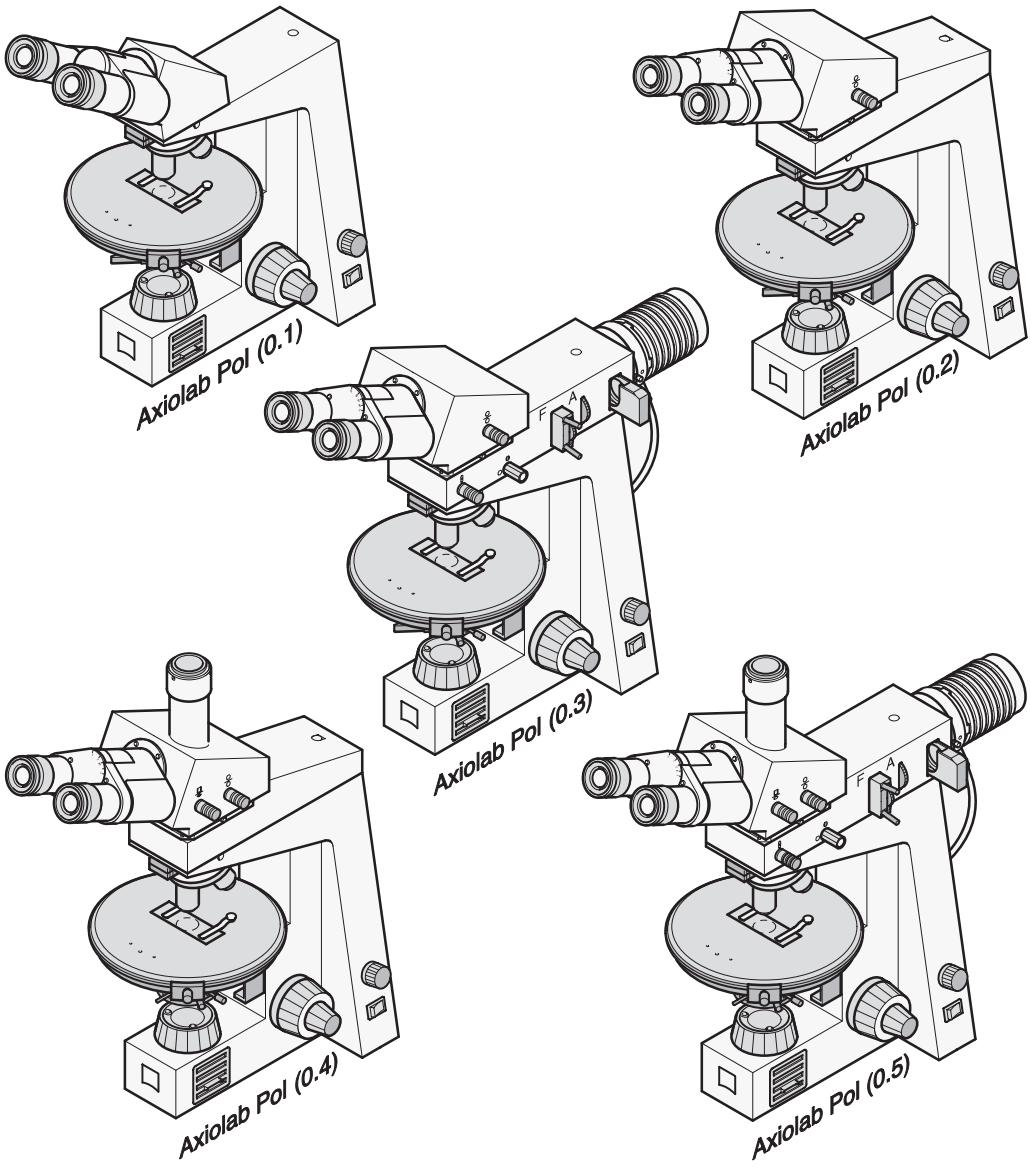
Axiolab Pol

Microscope



Operating manual

ZEISS

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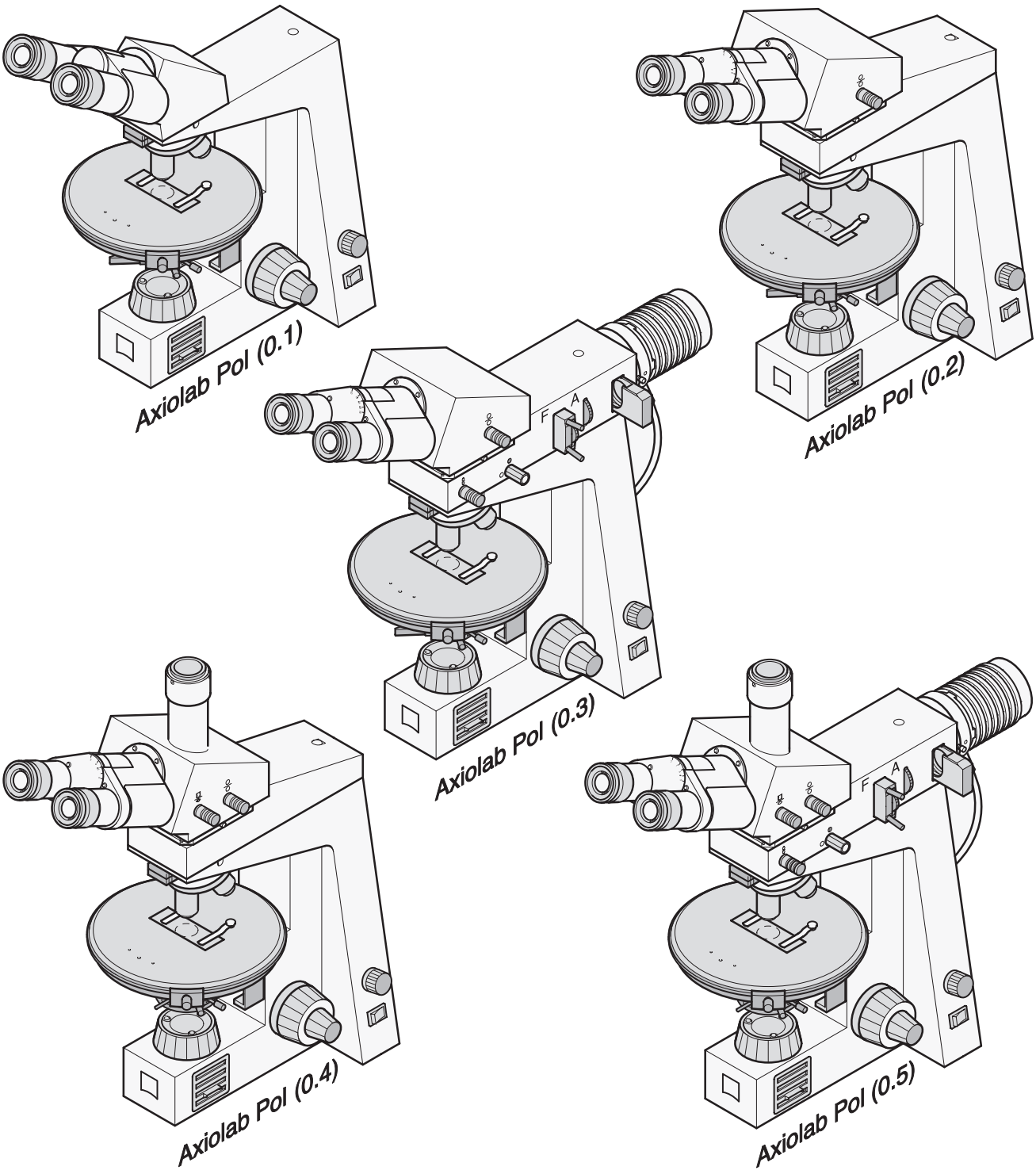
NOTE

- The figures integrated in the text each have a figure number and a caption, e.g. "Figure 2-3" signifies: the figure in Section 2 with the serial number 3. In each figure, details discussed in the text are assigned a reference line marking and an item number. In the running text, "rotary knob (2-3/8)" signifies: in Figure 3 of Section 2, the rotary knob is marked with the item number 8.

- Refer to the annex for explanations of the abbreviations.

GENERAL VIEW



NOTES ON DEVICE SAFETY

The Axiolab Pol microscopes including original accessories must only be used for the microscopy applications described in this manual.

The manufacturer cannot assume any liability for any other applications, possibly also involving individual modules or single parts. This also applies to all service or repair work that is not carried out by authorised service personnel. All guarantee/warranty claims also expire for all those parts that were not directly affected by repair.

Particular attention must be paid to the following warning notes:

- ☞ The Axiolab Pol microscopes were designed and tested in conformity with the IEC publication 1010-1, "Safety requirements for electrical instrumentation and control and laboratory apparatus", and were delivered in a safe state.
  This instruction manual contains information and warnings which must be followed by the operator.

- ☞ The Axiolab Pol microscopes are light microscopes conceived in accordance with the latest scientific and technical knowledge for visual, microphotographic and video analysis of microscopic specimens. The units must only be used for the intended purpose. They are not intended for continuous unsupervised operation!

- ☞ The microscopes have no special facilities to protect against samples that have caustic, toxic, radioactive or other effects that are damaging to health.

- ☞ The permissible sample mass ($\leq$ 2 kg) must not be exceeded.

- ☞ When handling immersion fluids and when cleaning the stage surface, make sure that no fluid penetrates into the mounting holes in the stage.

- ☞ To avoid dazzling, an attenuation filter must always be left in the beam path during bright field observation.
  It must not be removed from the beam path unless the light intensity is too low or when working with a crossed analyser and polariser.

- ☞ Users must check whether the available power supply agrees with the value specified on the rear of the unit.

☞ The Axiolab Pol microscopes are protective class I units.
The mains plug must only be inserted in a socket that is equipped with a protective earthing contact. This protective measure must not be rendered ineffective by using an extension cord without a PE conductor. If the mains voltage is adapted by means of a variable transformer, this transformer must not interrupt the PE conductor.
Any interruption of the PE conductor inside or outside the unit or disconnection of the protective earthing connection will involve a hazard for the user of the unit and is therefore forbidden.

☞ Internal protection terminals of the units may carry hazardous voltages when the microscopes are connected to the mains, and opening covers or removing parts (unless required for proper functioning) may possibly expose parts carrying a hazardous voltage. Therefore, the units must be disconnected from the mains before opening for adjustment, replacement, maintenance or repairs.
If adjustment, maintenance or repair of live units is unavoidable, this activity must be carried out by a specialist who is aware of the risk involved.

☞ Ventilation slots on the lamp housings must not be detrimentally affected by covering them up. This also applies to ventilation slots on the rear of the units. Tools, objects or liquids must not be allowed to penetrate into the units through ventilation slots or other openings on the units.
Before carrying out lamp replacement, remove the mains plug and allow it to cool to room temperature (cooling time approx. 15 min).
During operation, the lamp housings become hot and must therefore not be touched. If lamp housings are opened while warm, it is imperative to avoid touching the lamp and parts in its proximity.

☞ Make sure that only those fuses are used as spares for the unit fuses that are actually intended for the prescribed rated current and the specified version. It is forbidden to use provisional fuses or to short-circuit the fuse holders.

☞ If it is found that the protective measures are no longer effective, operation of the unit must be discontinued and it must be secured against unintentional operation. For repair of the microscope, contact a workshop authorised to carry out servicing or get in touch with the manufacturer.

☞ Modifications to the units to keep in line with technical progress are always reserved.

1 Description

1.1 Designation, purpose

Manufacturer's designation: upright polarisation microscope for training, for routine analyses and for research activities

The **Axiolab Pol** polarisation microscopes are light microscopes that can be used in research, industry and training for all application areas that call for polarisation-optical contrasting and determination of optical characteristics of primarily anisotropic, transparent and/or opaque materials, e.g. in

- geology (mineral and texture determination of natural and technical minerals, e.g. in the areas of petrography and salt petrography),
- chemistry (quality control of interim and end products, e.g. material testing of polymer and compound materials, moulded parts, fibres and films or pharmaceutical products),
- environmental research and analysis (phase and quantity analysis of recycling products, recycling materials, dust mixtures and asbestos fibres),
- medicine and biology (determination and composition of urinary calculi, urinary sediments, bio-crystallates and diagnosis of pathological characteristics),
- forensics (trace analysis of materials or of explosives, for example),
- building material analyses (determination of optical and thus mechanical characteristics on new and historic building substance, analyses of building ceramics),
- metallography and ceramics industry (analysis, phase analysis, structural analysis of metallic and ceramic materials in transmitted and reflected light).

1.2 Description of the unit

The Axiolab Pol microscopes are powerful laboratory microscopes that feature a compact design. An ergonomically favourable and clear arrangement of operator controls and a favourable viewing height with a 30° viewing angle ensure swift adaptation to the respective application task in research and teaching and also enable fatigue-free working when undertaking routine operations.

The microscopes are based on a modular structure, i.e. standard modules can be added effortlessly by fitting alternative modules or additional equipment.

The carrier element for this purpose is the stand, in which the transmitted light unit and the power supply are integrated.

1.2.1 Main assemblies and their characteristics

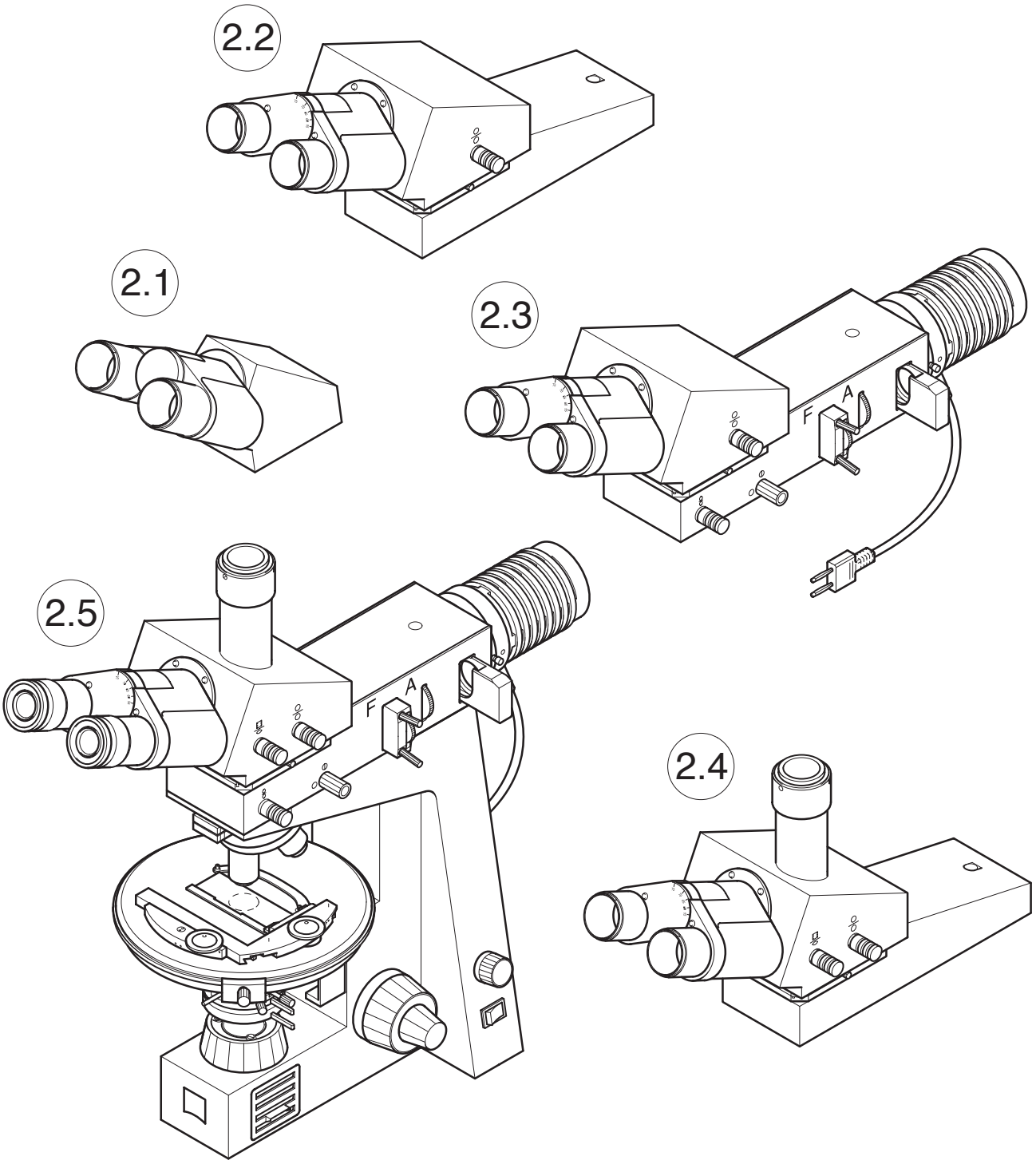


Figure 1-1 Main assemblies of the Axiolab Pol

- Axiolab Pol stand (450910)
  with integrated stabilised 25 W power supply for transmitted and reflected light, integrated transmitted light unit according to KÖHLER featuring a 6 V 25 W halogen lamp; fixed lens turret with 4-fold single centring; stage change position and coaxial coarse/fine drive, focusing acting on the specimen stage.
- Pol rotary stage with stage mount and condenser guide (453556)
  for stage set-ups and specimen heights up to a maximum of 29 mm; replaceable, e.g. by the universal rotary stage UD 124; any 45° latching position can be set; stage indexing via 0.1° vernier scale; with attachable Pol specimen guide for sensitive shifting and examination of specimens.
- Pol condenser
  optionally as a swivelling condenser 0.9 Z (445212) or as an achromatic-aplanatic condenser system 0.24/0.9 (445325).
- Polariser
  optionally with fixed orientation (453617) or rotatable with zero and 90° latching positions (453620).
- The power supply can be switched effortlessly by the customer between 115 V and 230 V.

Depending on the required ease of use, using various tube structures the Pol stand can be combined with the following features:

2.1 Binocular tube 35°/20 (452908)
with fixed-orientation analyser and compensator slide λ, optionally with depolariser.

2.2 Binocular tube 30°/20 Pol D (450967)
with reticule slaving on both sides, integrated depolariser, integrated fixed-orientation analyser that can be switched on and off, integrated fixed-focus BERTRAND lens and compensator aperture conforming to ISO 8040.

2.3 Binocular tube 30°/20 Pol D/A (450966)
with reticule slaving on both sides, integrated depolariser, integrated analyser with 0.1° indexing positions that can be switched on and off and rotated by 180°, integrated fixed-focus BERTRAND lens and compensator aperture conforming to ISO 8040, Pol reflected lighting with plane glass and switchable polariser/reflected light, replaceable reflected light lamp unit with 6 V 25 W halogen lamp.

2.4 Binocular photo tube 30°/20 Pol D (450964)
switchable between 100 % observation or 100 % photo/TV output, with reticule slaving on both sides, integrated depolariser, integrated analyser with 0.1° indexing positions that can be switched on and off and rotated by 180°, integrated fixed-focus BERTRAND lens and compensator aperture conforming to ISO 8040.

2.5 Binocular photo tube 30°/20 Pol D/A (450963)
switchable between 100 % observation or 100 % photo/TV output, with reticule slaving on both sides, integrated depolariser, integrated analyser with 0.1° indexing positions that can be switched on and off and rotated by 180°, integrated fixed-focus BERTRAND lens and compensator aperture conforming to ISO 8040, Pol reflected lighting unit with plane glass and switchable polariser/reflected light, replaceable reflected lighting unit with 6 V 25 W halogen lamp.

1.2.2 Optical structure of the Axiolab Pol (with reference to the example of the Axiolab Pol with binocular photo tube 30°/20 Pol D/A)

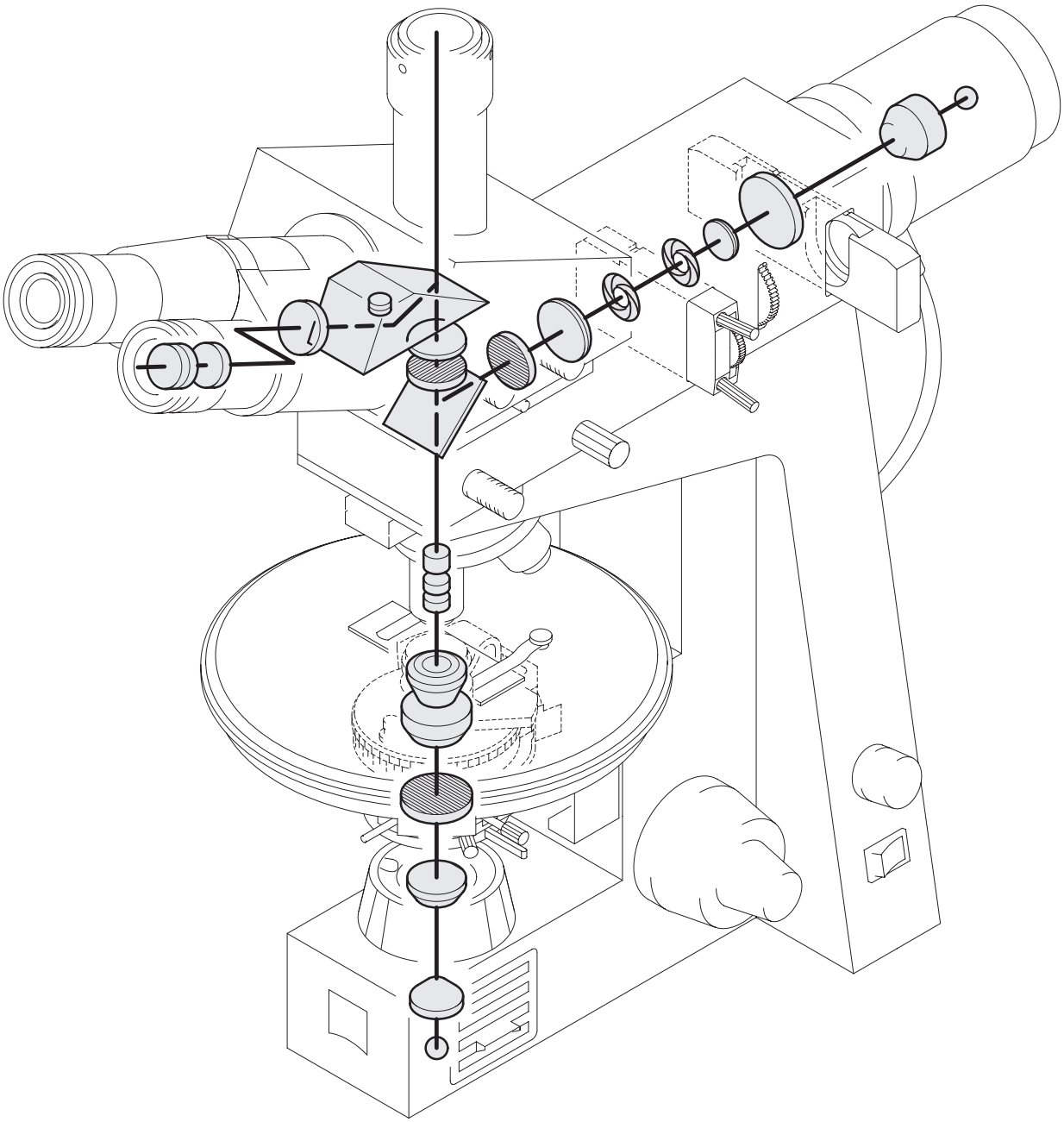


Figure 1-2 Optical schematic of the Axiolab Pol

The lamp voltage, and thus image brightness, can be controlled continuously by means of a rotary knob. The right colour temperature for colour photography (3,200 K) is reached at the end stop.

On the binocular tubes D/A, for reflected light operation the 6 V 25 W halogen lamp can be replaced by a 12 V 100 W halogen lamp or by a lighting unit XBO 75 or HBO 50.

A new polarisation optics system belonging to the proven ICS class (infinity colour-corrected system) guarantees a high optical output for all methods and homogeneous image fields for field of vision No. 20 with tube factor 1x.
It goes without saying that all other lenses in the ICS series can be used.

Two versions of the photo/TV output are available for the documentation of microscopic images. Microphotographic or video options are coupled by means of an extensive assortment of adapter components and assemblies.

1.3 Technical data

(1) Dimensions and mass

Dimensions (width x depth x height)

• Axiolab Pol with binocular tube 35°/20	Equipment 0.1)	180 x 245 x 415 mm
• Axiolab Pol with binocular tube Pol D	Equipment 0.2)	180 x 245 x 465 mm
• Axiolab Pol with binocular tube Pol D/A	Equipment 0.3)	180 x 375 x 465 mm
• Axiolab Pol with binocular photo tube Pol D	Equipment 0.4)	180 x 245 x 495 mm
• Axiolab Pol with binocular photo tube Pol D/A	Equipment 0.5)	180 x 375 x 495 mm

Viewing height

• Axiolab Pol with binocular tube 35°/20	Equipment 0.1)	410 mm
• Axiolab Pol with binocular tubes Pol	Equipment 0.2 – 0.5)	455 mm

Viewing angle

• Axiolab Pol with binocular tube 35°/20	Equipment 0.1)	35°
• Axiolab Pol with binocular tubes Pol	Equipment 0.2 – 0.5)	30°

Installation surface (recommended with support) ..... 440 x 310 mm

Mass ..... approx. 12 kg

(2) Ambient conditions

Storage and transport (in packaging)

Permissible ambient temperature ..... –40 to +70 °C

Permissible atmospheric pressure ..... 500 to 1060 mbar

Permissible sinusoidal vibrations ..... 10 to 150 Hz; 0.5 g

Permissible impacts (handling impacts) ..... 30 g; 6 ms

Operation

Permissible ambient temperature ..... +15 to +35 °C

Permissible relative humidity ..... < 75 %

Permissible atmosphericressure ..... 800 to 1060 mbar

Permissible impacts (handling impacts) ..... 10 g; 6 ms
100 impacts in operating position

(3) Operating data

Class of use ..... closed rooms

Class of protection ..... SK I

Type of protection ..... IP 20

Electrical safety ..... acc. IEC 1010-1 taking CSA and UL specifications into account

RFI suppression ..... acc. EN 55011 Class B

Interference resistance ..... acc. EN 50082

CE - the unit meets the requirements of the EC guideline 89/336/EWG and the EMC laws of 09.11.92 (see also EC conformity declaration, Annex Page A-5)

Mains voltage ..... switchable between 115 V and 230 V

Permissible mains voltage fluctuation ..... ±10 %

Mains frequency ..... 50/60 Hz

Mains voltage range identification ..... on fuse holder/rear of unit

Power consumption ..... 60 VA

(4) Light source

Halogen lamp with square flat core filament ..... HAL S 5 A 6 V 25 W

Lamp voltage (variable) ..... >1.5 V to max. 6 V

Output ..... 25 W

Colour temperature at end stop ..... 3200 K

Luminous flux at 6 V ..... 510 lm

Average useful life at 6 V / 4.8 V ..... 100 h/2000 h

Reflected light lamp (equipment 0.3 and 0.5) ..... replaceable by

- lighting unit HAL 100 W (option)
- lighting unit XBO 75 (option)
- lighting unit HBO 50 (option)

(5) Optical/mechanical data

Specimen focusing ..... coaxial coarse/fine drive
Stroke: 20 mm
Coarse drive: 4.0 mm/turn
Fine drive: 0.4 mm/turn

Lens change ..... manually with a 4-fold lens turret with single centring

Lenses ..... stress-free reflected and transmitted light ICS lens set for the contrast methods HF, POL and FL

Eyepieces ..... Eyepiece E-Pl 10x/20 spec. foc.
Eyepiece E-Pl 10x/20 spec. foc. Pol with integrated and oriented reticule

Binocular tubes (equipment 0.1 to 0.5) ..... pupil distance adjustable from 55 to 75 mm, tube factor 1x

Maximum possible field of vision diameter ..... 20 mm

in addition to binocular tubes Pol (equipment 0.2 to 0.5) ..... with integrated BERTRAND lens and reticule slaving on both sides

in addition to binocular photo tubes Pol ..... photo output 100 % (equipment 0.4 and 0.5)

Stage version ..... rotary stage Pol held on a ball bearing with integrated 45° latching, stage carrier and condenser mount

Maximum specimen height

- Stage at bottom stop ..... 29 mm
- Stage at top stop ..... 20 mm

1.4 Overview of assemblies

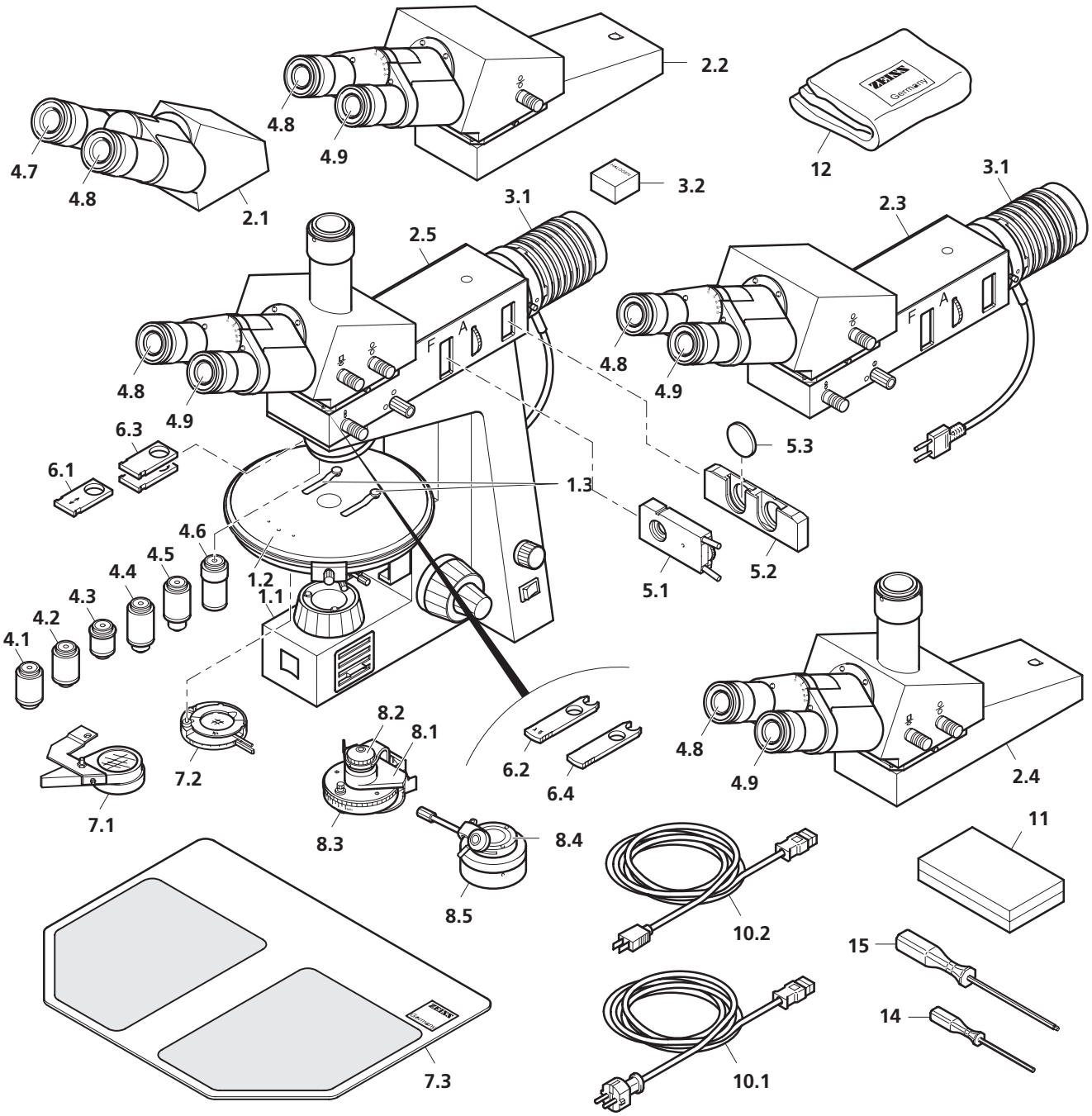


Figure 1-3 Axiolab Pol microscope equipment

l

ol microscope equipment	Order No.	0.1	0.2	0.3	0.4	0.5
olab Pol with binocular tube 35°/20	490970 9804	●				
olab Pol with binocular tube 30°/20 Pol D	490973 9804		●			
olab Pol with binocular tube 30°/20 Pol D/A	490975 9804			●		
olab Pol with binocular photo tube 30°/20 Pol D	490977 9804				●	
olab Pol with binocular photo tube 30°/20 Pol D/A	490979 9804					●
olab Pol microscope stand	450910	●	●	●	●	●
ary stage Pol with stage carrier	453556	●	●	●	●	●
2x stage springs (B 6 /50 ZN 2278)		●	●	●	●	●
ocular tube 35°/20	452908	●				
ocular tube 30°/20 Pol D (with fixed analyser)	450967		●			
ocular tube 30°/20 Pol D/A (with rotating analyser)	450966			●		
ocular photo tube 30°/20 Pol D (with rotating analyser)	450964				●	
ocular photo tube 30°/20 Pol D/A (with rotary analyser)	450963					●
p 6 V 25 W / A	447206			●		●
ogen lamp HAL S 5 A 6 V 25 W	417030 9001	●	●	●	●	●
-Neofluar 2.5 x / 0.075 Pol	440313				●	●
Achromat 5 x / 0.12 Pol	440923	●	●	●		
Plan 10 x / 0.20 Pol	442933	●	●	●	●	●
Achromat 20 x / 0.40 Pol	440943	●	●		●	
Achromat 50 x / 0.80 Pol	440953 9901		●	●	●	●
Plan 50 x / 0.70 Pol	442953			●		●
piece E-Pl 10 x / 20 spec.	444231 9901	●				
piece E-Pl 10 x / 20 spec. foc.	444232 9902	●	●	●	●	●
piece E-Pl 10 x / 20 spec. foc. Pol	444037 9901		●	●	●	●
inous field diaphragm slide	integr. in 2.3 a. 2.5			●		●
r slide	integr. in 2.3 a. 2.5			●		●
tral filter N = 0.06, d = 32 x 2	467848 9001	●	●	●	●	●
tral filter N = 0.25, d = 32 x 1.5 – not illustrated –	467849			●		●
version filter B 12, d = 32 x 2 – not illustrated –	467850 9901				●	●

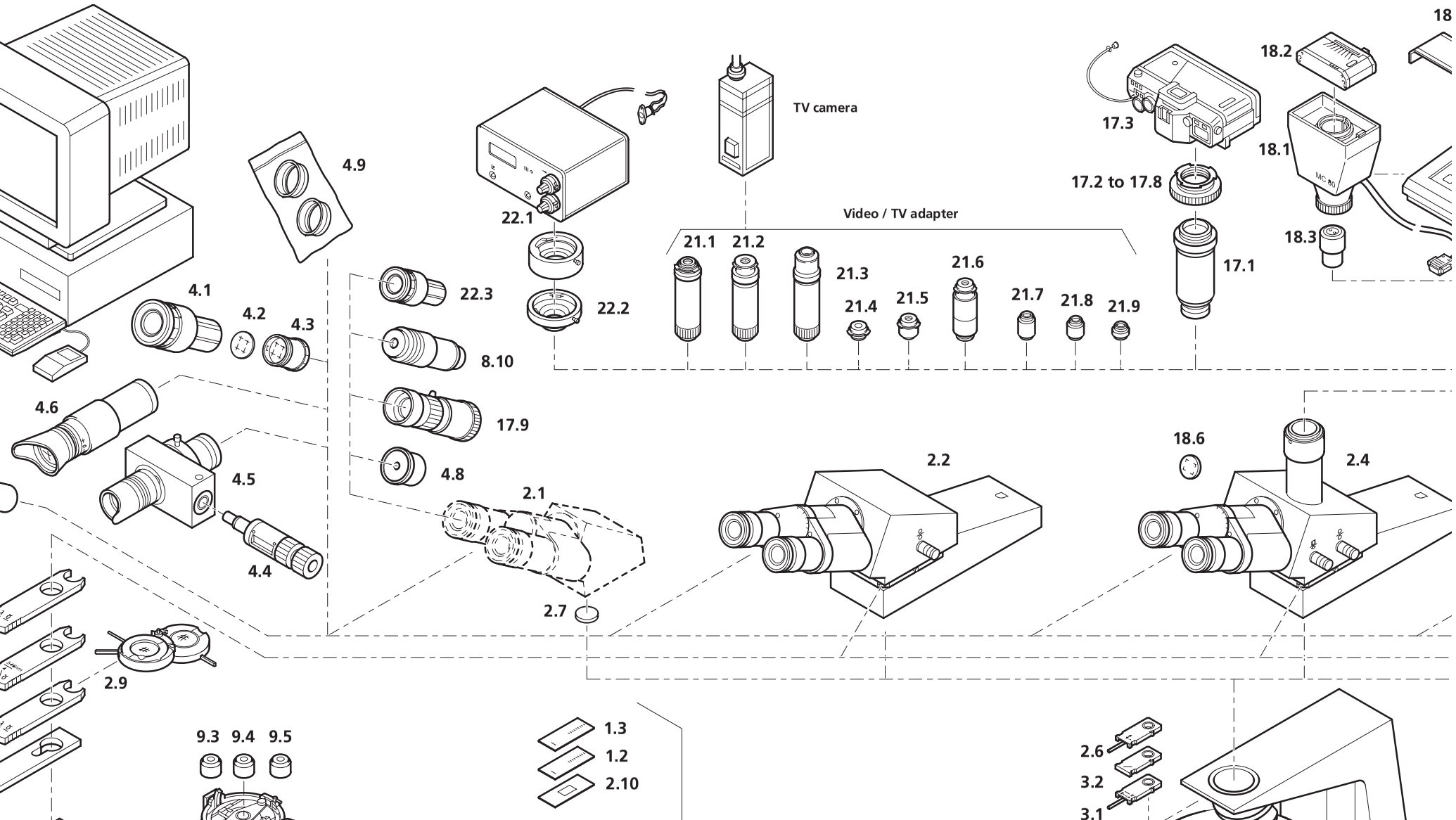
7.2	Polariser D, rotating

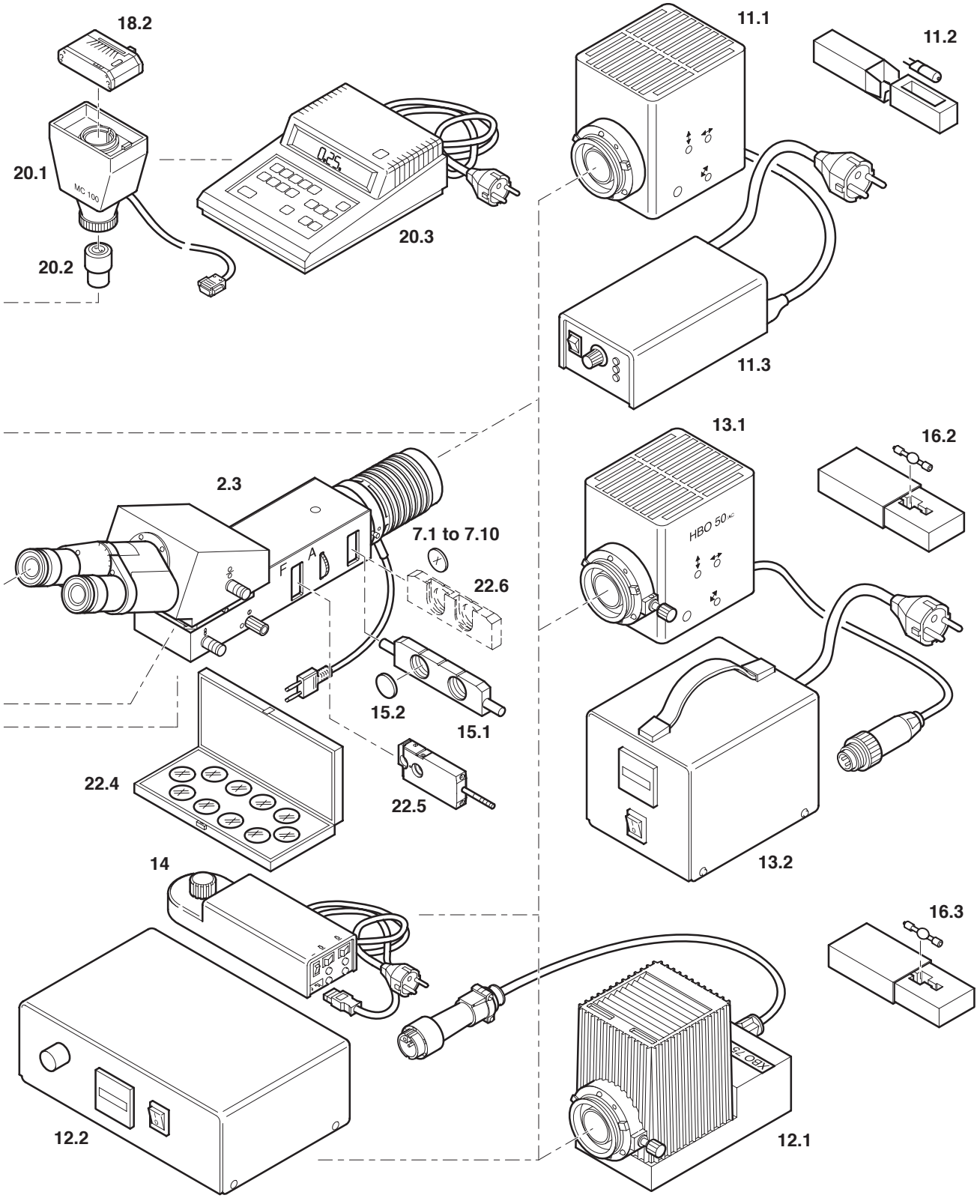
Axiolab Pol microscope equipment

8.1	Achromatic-aplanatic system condenser 0.24 / d = 10.7; swivelling Pol
8.2	Front optics 0.9 / d = 2.9 Pol
8.3	Bright field insert
8.4	Condenser 0.9 Z Pol swivelling
8.5	Condenser adapter for Axiolab Pol
9	Eye cup – not illustrated –
10.1	Mains cable with European plug
10.2	Mains cable with American flat plug
10.3	G-fuse link (5 x 20) mm to IEC 127 230 V: T 0.4 A / 250 V – not illustrated –
10.4	G-fuse link (5 x 20) mm to IEC 127 115 V: T 0.8 A / 250 V – not illustrated –
11	Accessory receptacle
12	Dust protection sleeve G
13	Support

.5	2x	000000-0096.710	●	●	●	●	●
wdriver 368 / a/f 3		000000-0069.551	●	●	●	●	●

● Part of the microscope equipment


TV camera
Video / TV adapter
4.9
22.1
22.2
22.3
8.10
17.9
4.8
2.1
2.7
4.1
4.2
4.3
4.6
4.5
4.4
2.9
21.1
21.2
21.3
21.4
21.5
21.6
21.7
21.8
21.9
17.3
17.2 to 17.8
17.1
18.2
18.1
18.3
18
2.2
18.6
2.4
9.3
9.4
9.5
1.3
1.2
2.10
2.6
3.2
3.1


18.2
20.1
MC 100
20.2
20.3
11.1
11.2
11.3
2.3
7.1 to 7.10
22.6
15.2
15.1
22.4
22.5
13.1
HBO 50 AC
16.2
13.2
14
12.2
16.3
XBO 75
12.1

Accessories for the Axiolab Pol microscope equipment		Order No.	0.1	0.2	0.3	0.4	0.5
0.1	Axiolab Pol with binocular tube 35°/20	490970 9804	●				
0.2	Axiolab Pol with binocular tube 30°/20 Pol D	490973 9804		●			
0.3	Axiolab Pol with binocular tube 30°/20 Pol D/A	490975 9804			●		
0.4	Axiolab Pol with binocular photo tube 30°/20 Pol D	490977 9804				●	
0.5	Axiolab Pol with binocular photo tube 30°/20 Pol D/A	490979 9804					●
1.1	Specimen guide Pol	473325 9904	▲	▲	▲	▲	▲
1.2	Specimen micrometer for transmitted light 5+100/100y, D=0.17	474026	▲	▲	▲	▲	▲
1.3	Specimen micrometer for reflected light 5+100/100y, D=0	474027			▲		▲
2.2	Binocular tube 30°/20 D (with fixed analyser)	450967	▲				
2.3	Binocular tube 30°/20 D/A (with rotating analyser)	450966	▲	▲			
2.4	Binocular photo tube 30°/20 D (with rotating analyser)	450964	▲	▲	▲		
2.5	Binocular photo tube 30°/20 D/A (with rotating analyser)	450963	▲	▲	▲	▲	
2.6	Analyser, rotating ±5°, 6 x 25	453685	▲				
2.7	Depolariser	453675	▲				
2.8	Polariser D, rotating	453620	▲	▲	▲		
2.9	Circular polariser D	453623		▲	▲	▲	▲
2.10	Adjustment specimen Pol	453679	▲				
3.1	Compensator λ, rotating ±5°, 6 x 25	453705	▲				
3.2	Compensator λ, 6 x 25	453711	▲				
3.3	Compensator λ/4, 6 x 20	453714		▲	▲	▲	▲
3.4	Wedge compensator 0 ... 3 λ	453724		▲	▲	▲	▲
3.5	Compensator λ, rotating ±10°, 6 x 20	453712		▲	▲	▲	▲
3.6	SENARMONT compensator 546: 4, 6 x 20	453718			▲	▲	▲
3.7	Narrow band filter SB 546/2, d = 32 mm	260201 5600.426			+	+	+
3.8	Tilting compensator EHRINGHAUS 0 ... 6 λ	453720		▲	▲	▲	▲
3.9	Tilting compensator EHRINGHAUS 0 ... 130 λ	453722		▲	▲	▲	▲
3.10	Rotary compensator BRACE-KÖHLER λ/8	453721		▲	▲	▲	▲
4.1	Eyepiece E-Pl 10x/20 spec. foc. (for reticule + division)	444232 9902	▲	▲	▲	▲	▲
4.2	Reticule micrometer 14: 140, d = 26 mm	454060	+	+	+	+	+
4.3	Diaphragm part, screw-in	444232 0206	+	+	+	+	+
	Digital eyepiece measuring unit, consisting of:		▲	▲	▲	▲	▲
4.4	Digital micrometer 46 EH	414001 9015	+	+	+	+	+
4.5	Micrometer eyepiece 20x	444142	+	+	+	+	+
4.6	Additional eyepiece 20x	444141	+	+	+	+	+
4.7	Drawing eyepiece 8x	444126	▲	▲	▲	▲	▲
4.8	Diopter, d = 30 mm	444020	▲				

Accessories for the Axiolab Pol microscope equipment			Order No.	0.1	0.2	0.3	0.4	0.5
4.9	Eye cup	2x	444801	▲	▲		▲	
	Lenses:							
5.1	Plan-Neofluar	1.25 x / 0.04	440300				▲	▲
5.2	Plan-Neofluar	2.5 x / 0.075 Pol	440313	▲	▲	▲		
5.3	Epiplan-Neofluar	2.5 x / 0.075 Pol	442313			▲		▲
5.4	Antiflex cap for lens	2.5 x	444922			▲		▲
5.5	CP-Achromat	5 x / 0.12 Pol	440923				▲	▲
5.6	Plan-Neofluar	5 x / 0.15 Pol	440323	▲	▲		▲	
5.7	Epiplan-Neofluar	5 x / 0.15 Pol	442323			▲		▲
5.8	CP-Achromat	20 x / 0.40 Pol	440943			▲		▲
5.9	Plan-Neofluar	20 x / 0.50 Pol	440343			▲		▲
5.10	Epiplan-Neofluar	20 x / 0.50 Pol	442343			▲		▲
5.11	CP-Achromat	50 x / 0.80 Pol	440953-9901	▲				
5.12	Epiplan-Neofluar	50 x / 0.85 Pol	442353			▲		▲
5.13	Plan-Neofluar	100 x / 1.30 Oil Pol	440483		▲	▲	▲	▲
5.14	Epiplan-Neofluar	100 x 0.9 Pol	442383			▲		▲
5.15	Epiplan-Neofluar	100 x / 1.30 Oil Pol	442483			▲		▲
5.16	Epiplan-Neofluar	20 x / 0.65 Oil Pol	442483			▲		▲
5.17	Epiplan-Neofluar	50 x / 1.00 Oil Pol	442453			▲		▲
5.18	Mirau interference unit for LD 20		444942			▲		▲
5.19	Oiler with 50 ml immersion oil nD 1.515 – PCP-free –		444942		▲	▲	▲	▲
6.1	Achr.-apl. system condenser 0.24 / d = 10.7 Pol, swivelling		445325	▲	▲	▲		
6.2	Front optics 0.9 / d = 2.9 Pol		445331	+	+	+		
6.3	Bright field insert		445364	+	+	+		
6.4	Front optics 1.4 / d = 1.9 Pol		445332		▲	▲	▲	▲
6.5	Front optics 0.6 / d = 4.2 LD Pol		445330		▲	▲	▲	▲
6.6	Overview unit, swivelling, d = 16 for 1.25x lens		445313				▲	▲
	Filters:							
7.1	Neutral filter N = 0.25, d = 32 x 2		467849	▲	▲		▲	
7.2	Grey filter 0.5, d = 32 x 4		467840				▲	▲
7.3	Grey filter 0.12, d = 32 x 4		467841				▲	▲
7.4	Grey filter 0.03, d = 32 x 4		467842				▲	▲
7.5	Conversion filter CB 12, d = 32 x 2		467850 9001	▲	▲	▲		
7.6	Conversion filter CB 6, d = 32 x 2		467851				▲	▲
7.7	Conversion filter CB 3, d = 32 x 2		467852				▲	▲
7.8	Conversion filter 3200 - 5500K, d = 32 x 2		467847				▲	▲
7.9	Narrow band filter SB 546/2, d = 32 mm		260201-5600.426		▲	▲	▲	▲
7.10	Filter set SB, d = 32 mm		260201-5601.524		▲	▲	▲	▲

Accessories for the Axiolab Pol microscope equipment		Order No.	0.1	0.2	0.3	0.4	0.5
7.11	Coloured glass carrier (filter holder, swivelling)	451834	▲	▲		▲	
	Phase contrast:						
8.1	ABBE condenser 0.9/1.25 with turret disk	455303	▲	▲	▲		
	Recommended Ph lenses:						
8.2	Achroplan 10 x / 0.25 Ph 1	440031	▲	▲	▲	▲	▲
8.3	Plan-Neofluar 40 x / 0.75 Ph 2	440351	▲	▲	▲	▲	▲
8.4	Achroplan 100 x / 1.25 Oil Ph 3	440081	▲	▲	▲	▲	▲
	Phase contrast in conjunction with 6.1/6.2:						
8.5	Turret disk H, D, Ph	445366				▲	▲
8.6	Ring diaphragm 1 / 0.9	445369				▲	▲
8.7	Ring diaphragm 2 / 0.9	445370				▲	▲
8.8	Ring diaphragm 3 / 0.9	445371				▲	▲
8.9	Interference wide band filter, green, d = 32 x 4	467803	▲	▲	▲	▲	▲
8.10	Auxiliary microscope, d = 30 mm	444830	▲	▲	▲	▲	▲
	Transmitted light dark field (limit dark field): for lens 10 x / 0.20, ring diaphragm Ph 2 in:						
8.1	ABBE condenser 0.9/1.25 with turret disk	455303	▲	▲	▲		
8.5	**or** in conjunction with 6.1/6.2: Turret disk H, D, Ph	445465	▲	▲	▲	▲	▲
8.11	**and** dark field diaphragm 0.75 / 0.9	445399	▲	▲	▲	▲	▲
	(please enquire about further possibilities with special dark field condensers)						
9	**Universal rotary stage equipment, consisting of:**		▲	▲	▲	▲	▲
9.1	Universal rotary stage UD 124	453566	+	+	+	+	+
9.2	UD condenser 0.6 Pol	445311	+	+	+	+	+
9.3	Achromat UD 5 x / 0.13 Pol (for segment)	442001	+	+	+	+	+
9.4	Achromat UD 20 x / 0.30 Pol (for segment)	442003	+	+	+	+	+
9.5	Achromat UD 50 x / 0.60 Pol (for segment)	442005		▲	▲	▲	▲
10	**Equipment for heating chambers:**						
10.1	LD-Achroplan 20 x / 0.40 (D = 1.2 - 1.8)	440840	▲	▲	▲	▲	▲
10.2	LD-Achroplan 32 x / 0.40 (D = 1.2 - 1.8)	440850	▲	▲	▲	▲	▲
10.5	plus: cover glass cap D = 0.6 - 1.2	444931	▲	▲	▲	▲	▲
10.6	or: cover glass cap D = 0 - 0.6	444930	▲	▲	▲	▲	▲
10.3	LD-Epiplan 20 x / 0.40 (D=0 and 1.5)	442840			▲		▲
10.4	LD-Epiplan 50 x / 0.50 (D= 0)	442850			▲		▲
	(Please enquire about LD phase contrast lenses.)						
9.2	UD condenser 0.6 (0.4 without segment) Pol	445311	▲	▲	▲	▲	▲

	Accessories for the Axiolab Pol microscope equipment	Order No.	0.1	0.2	0.3	0.4	0.5
	for 6.1: front optics 0.6 / d = 4.2 LD Pol	445330	▲	▲	▲	▲	▲
	(Please enquire about heating chambers from -196° to 1500° from Messrs. Linkam und Mettler.)						
11	**Lighting unit HAL 12 V 100 W, consisting of:**				▲		▲
11.1	Halogen lamp HAL 12 V/100 W	447218			+		+
11.2	Halogen lamp 12 V 100 W	380079 9540			+		+
11.3	Additional power supply unit 12 V DC 100 W, stabilised	45 8417			+		+
12	**Lighting unit XBO 75**	487202 9804			▲		▲
12.1	Xenon lamp XBO 75 W				▲		▲
12.2	HF ballast XBO 75 W HBO 100 W	458450			▲		▲
13	**Lighting unit HBO 50 (220 V)**	487201 9804			▲		▲
13.1	Mercury vapour lamp HBO 50 W				▲		▲
13.2	Power supply unit	392642			▲		▲
	Intermediate transformer, 1200 VA (not illustrated)	392589			▲		▲
14	Power supply 6 V 10 ... 40 W, 230 V, variable, 50 VA (2 outputs switchable) for mixed light observation	458420			▲		▲
	Epode fluorescence for Axiolab Pol, consisting of:				▲		▲
15.1	Filter slide (for filters d = 25 mm) FL	446478			+		+
15.2	IF blue filter BP 450-490, 25 x 3B – for excitation –	447722			+		+
15.3	Orange filter LP 520, d = 18 x 2 – as blocking filter –	467873			+		+
15.4	Sealing and filter slide 6 x 20	473790 9901			+		+
14	Power supply 6 V 10 ... 40 W, 230 V, variable, 50 VA (2 outputs switchable) for mixed light observation	458420			▲		▲
13	Lighting unit HBO 50 (220 V)	487201 9804			▲		▲
	Intermediate transformer, 1200 VA (not illustrated)	392589			▲		▲
16.1	Halogen lamp 6 V 25 W	417030 9001	▲	▲	▲	▲	▲
11.2	Halogen lamp 12 V 100 W	380079 9540			▲		▲
16.2	Mercury vapour short arc lamp HBO 50	381619			▲		▲
16.3	Xenon lamp XBO 75 W/2 – 381620 – (ozone-free)	380053 9870			▲		▲
	Equipment for 35 mm SLR camera, consisting of:					▲	▲
17.1	Connector for single lens reflex camera 2.5 x for T2	456005				+	+
17.2	T2 adapter for CONTAX (Contax bayonet)	416010				▲	▲
17.3	Single lens reflector camera housing CONTAX 167 MT	416181				▲	▲
17.4	T2 adapter for OLYMPUS OM (OM bayonet)	416002				▲	▲
17.5	T2 adapter for MINOLTA (SR bayonet)	416003				▲	▲
17.6	T2 adapter for CANON (FD bayonet)	416004				▲	▲
17.7	T2 adapter for NIKON (F bayonet)	416009				▲	▲
17.8	T2 adapter for PENTAX (KA bayonet)	416011				▲	▲
17.9	Monocular binoculars 3 x 12 B - as an adjustment aid for low lens magnification factors	522012				▲	▲

	Accessories for the Axiolab Pol microscope equipment	Order No.	0.1	0.2	0.3	0.4	0.5
	Microscope camera equipment MC 80 for miniature photography 24 x 36, consisting of:					▲	▲
18.1	Base MC 80	456011				+	+
18.2	Film cartridge, 35 mm Mot	456070				+	+
18.3	Projection lens P 2.5 x for MC 80	456021				+	+
18.4	Microscope camera connector d = 30 mm	456006				+	+
18.5	Exposure control MC 80, plus mains cable with European plug	456047				+	+
		380137 6750				+	+
18.6	Format reticule plate MC 10 x d = 26 mm and	454075				+	+
4.3	Diaphragm part, screw-in, or	444232-0206				+	+
4.1	Eyepiece E-Pl 10x/20 foc. with	444232-9902				▲	▲
18.6	Format reticule plate MC 10 x d = 26 mm	454075				+	+
18.7	Data-Back (for film cartridge, 35 mm Mot)	456074				▲	▲
	Microscope camera equipment MC 80 for large-format photography 4 x 5", consisting of:					▲	▲
18.1	Base MC 80	456011				+	+
19.1	Camera attachment M 4" x 5" (MC 80 / MC 100)	456056				+	+
19.2	Projection lens P10x for MC 80	456023				+	+
18.4	Microscope camera connector d = 30 mm	456006				+	+
18.5	Exposure control MC 80, plus	456047				+	+
	mains cable with European plug	380137 6750				+	+
18.6	Format reticule plate MC 10 x d = 26 mm and	454075				+	+
4.3	Diaphragm part, screw-in, or	444232-0206				+	+
4.1	Eyepiece E-Pl 10x/20 spec. foc. with	444232-9902				▲	▲
18.6	Format reticule plate MC 10 x d = 26 mm	454075				+	+
19.3	Double flat film cartridge 4" x 5"	416131				▲	▲
19.4	Polaroid-Land flat film cartridge pack 550 for 4" x 5"	416127				▲	▲
19.5	Polaroid-Land flat film cartridge pack 545 for 4" x 5"	416128				▲	▲
	Microscope camera equipment MC 100 spot for miniature photography 24 x 36, consisting of:					▲	▲
20.1	Base MC 100 Spot	456014				+	+
18.2	Film cartridge, 35 mm Mot	456070				+	+
20.2	Photo eyepiece S-Pl 10 x / 20	444039				+	+
18.4	Microscope camera connector / d = 30 mm	456006				+	+
20.3	Exposure control MC 100	456049				+	+
18.6	Format reticule plate MC 10 x / d = 26 mm and	454075				+	+
4.3	Diaphragm part, screw-in, or	444232-0206				+	+
4.1	Eyepiece E-Pl 10x/20 spec. foc. with	444232-9902				▲	▲
18.6	Format reticule plate MC 10 x / d = 26 mm	454075				+	+
	C-mount TV adapter for 1-chip CCD cameras – b/w and colour						
21.1	TV adapter 60 C 2/3" 1.0x	456105				▲	▲
21.2	TV adapter 60 C 2/3" 0.63x	456107				▲	▲

Accessories for the Axiolab Pol microscope equipment		Order No.	0.1	0.2	0.3	0.4	0.5
21.3	TV adapter 60 C 1/2" 0.5x	456106				▲	▲
21.4	Video zoom adapter 0.4x - 2x C-mount	456123				▲	▲
	TV adapter ENG for 3-chip CCD cameras – colour / high-resolution						
21.5	TV adapter 60 ENG 2/3" 1.0x	456115				▲	▲
21.6	TV adapter 60 ENG 2/3" 0.8x	456117				▲	▲
21.7	Video zoom adapter 0.4x – 2x 2/3" ENG	456121				▲	▲
21.8	TV adapter 60 ENG 1/2" 0.63x	456118				▲	▲
21.9	Video zoom adapter 0.4x – 2x 1/2" ENG	456122				▲	▲
	Microscope photometer equipment MPM 100, consisting of:						
22.1	Attachment photometer MPM 100	457325				▲	▲
22.2	Attachment piece 60-44	456140				+	+
22.3	Eyepiece E-Pl 10x/20 P spec. foc. with integrated eyepiece circle plate P, d = 26 mm	444092 9901				+	+
22.4	Set of hole diaphragms	477380				+	+
22.5	Slide A for fixed diaphragms	457378				▲	▲
22.6	Reflection-type heat protection filter, d = 32 x 2	467832				▲	▲
22.7	PC accessories MPM 100	457326				▲	▲
22.8	Reflection standard NG1 (not illustrated)	474250 8032					▲
22.9	Reflection standard SiC (not illustrated)	474251 8033					▲

Accessories for the Axiolab Pol microscope equipment		Order No.	0.1	0.2	0.3	0.4	0.5
	Adaptation for spectral photometer	please inquire					
23	Grind press	478962			▲		▲

+ Units that are absolutely necessary for the accessories "▲" listed above them

2 Operation

2.1 Setting up the unit

The basic **Axiolab Pol** unit in its five variants, including accessories, is delivered in commercially usual packaging.
It is advisable to keep the transport receptacles in case prolonged storage or returning to the manufacturer should be necessary.

(1) Preparations

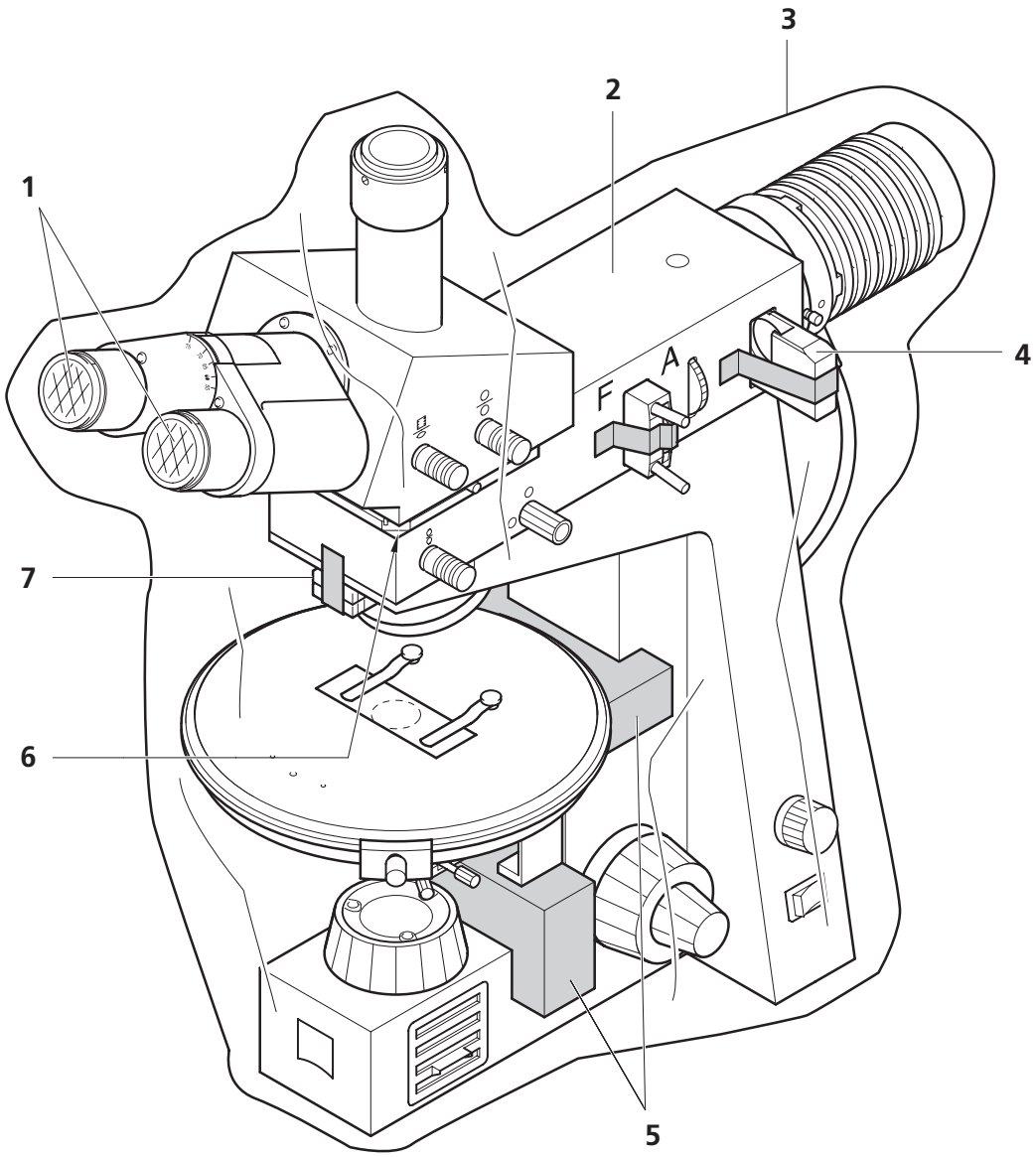


Figure 2-1 Setting up the microscope

- Remove the microscope from the transport receptacle and place it on the intended place of work.
- Remove the plastic sleeve (2-1/3) from the unit.
- Remove the transport lock (2-1/5).
- Remove adhesive strips that secure the various operator controls during transport.
- Allow the unit to adapt to room temperature for a few hours after prolonged storage or transport.
- Dust protection or process slides (2-1/4, 6, 7) inserted in the unit remain inside it.
- Remove dust caps (2-1/1) and, instead, insert eyepieces in the binocular tube.

HINWEIS Pay attention to Section 2.4 (3) when inserting the eyepiece E-Pl 10x/20 Pol (444037) in the binocular tube.

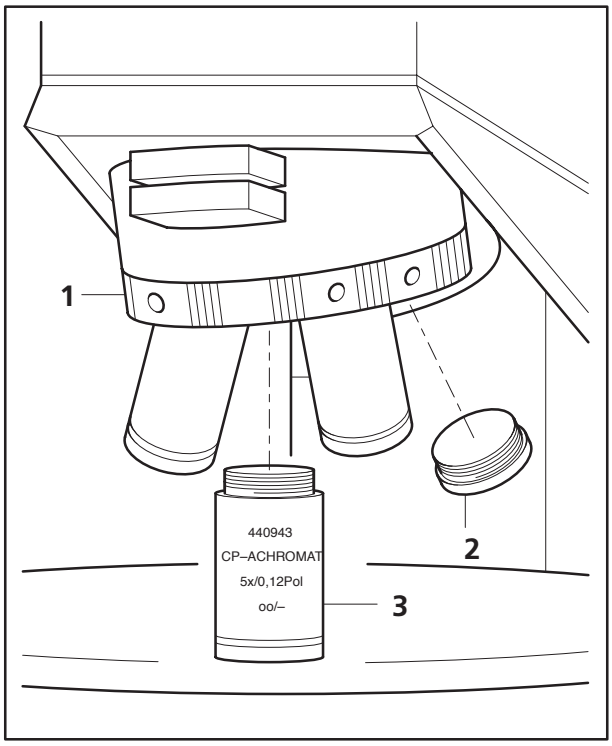


Figure 2-2 Screwing in lenses

(2) Screwing in lenses

Corresponding to the number of lenses, undo the dust caps (2-2/2) and screw the lenses with ascending magnification factors (2-2/3) – beginning with the weakest magnification in clockwise direction – into the lens turret (2-2/1).
Lens openings in the lens turret that are not needed must be kept sealed by the dust protection caps.

IMPORTANT The polarisation lenses (marked red) have a stress-free structure. They are susceptible to pressure and impacts. You are advised **only** to use the knurl on the lens turret when replacing lenses.

(3) Inserting the condenser

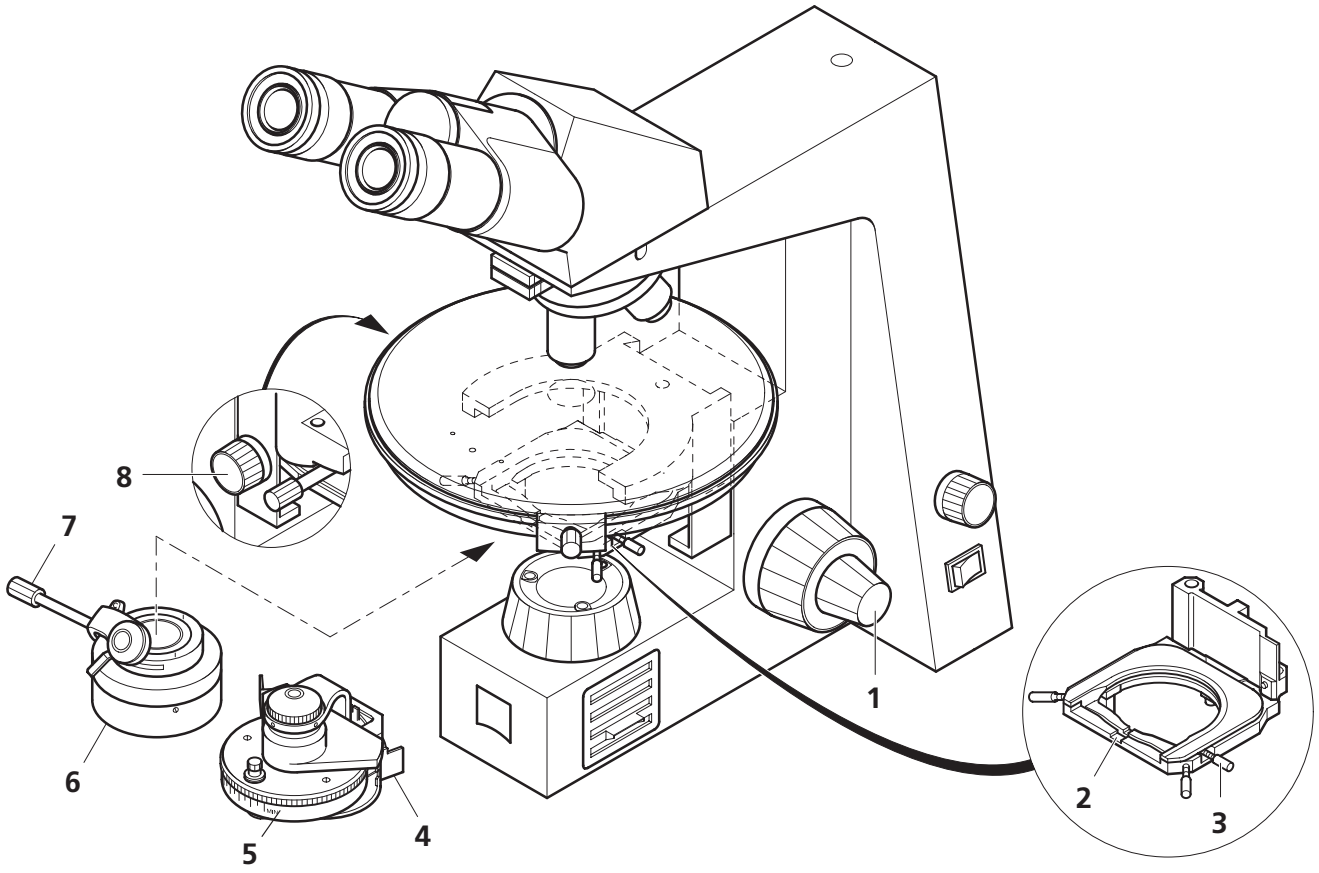


Figure 2-3 Inserting the condenser

- Remove the condenser Pol from the packaging.
- By means of the coarse drive (2-3/1), raise the rotary stage Pol to the stop position.
- After lowering the condenser drive via the rotary knob (2-3/8) and by undoing the screw (2-3/3), insert the condenser from the front into the guide fork; to do this, tilt down the front optics if necessary (shift lever (2-3/4 or 7)).

  NOTE The notch (2-3/2) in the condenser carrier orients the condenser. The condenser 0.9 Z Pol (445212) must be oriented so that the switching element (2-3/7) under the stage carrier points horizontally to the left.

- Fix the condenser with the clamping screw (2-3/3) and move it to the proximity of the top stop by means of the rotary knob (2-3/8).

(4) Fitting the lamp HAL 25 (for equipment 0.3 and 0.5 only)

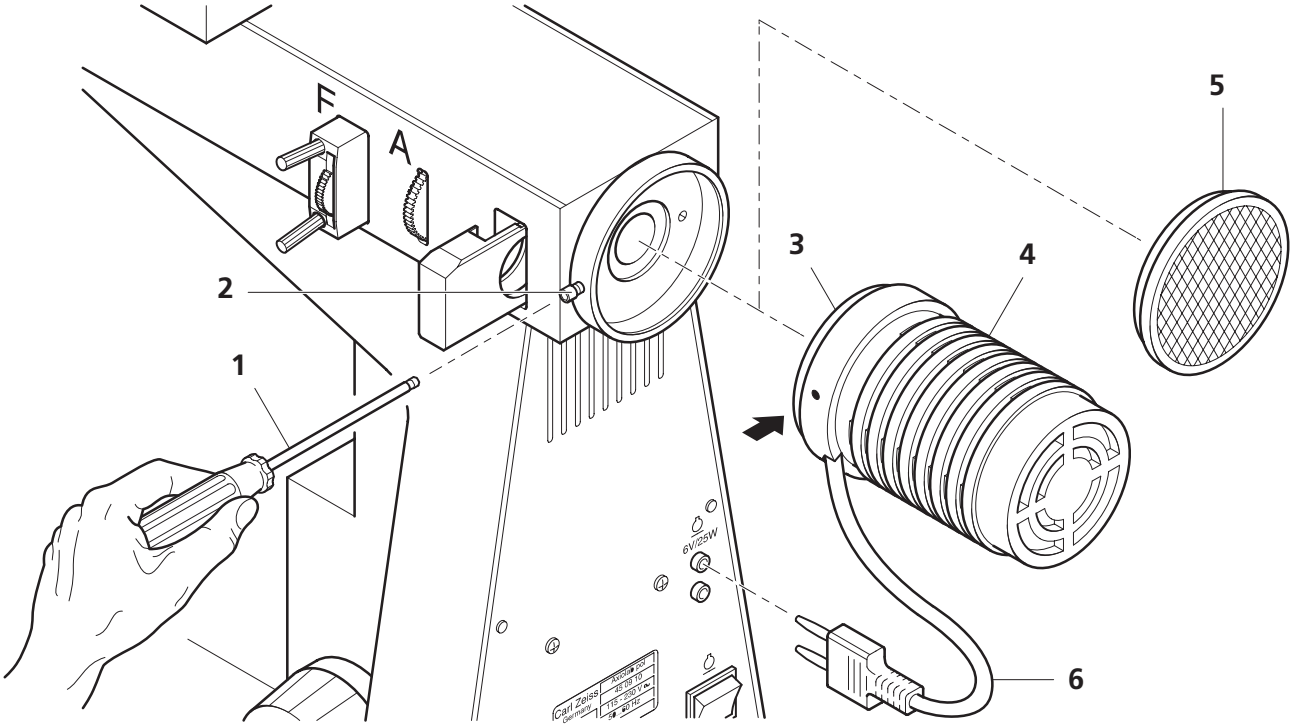


Figure 2-4 Fitting the reflected light lamp

- Detach the dust protection cover (2-4/5).
- To do this, undo the hexagon screw (2-4/2) (ball head screwdriver (2-4/1)) and position the lamp HAL 25 (2-4/4) with the dovetail guide (2-4/3); tighten the hexagon screw (2-4/2) again.

NOTE Position the lamp so that the black orientation point on the lamp (see arrow) is at the same level as the screw (2-4/2).

- Plug the connecting cable (2-4/6) into the socket on the rear of the unit.

(5) Filter slide (for equipment 0.3 and 0.5 only)

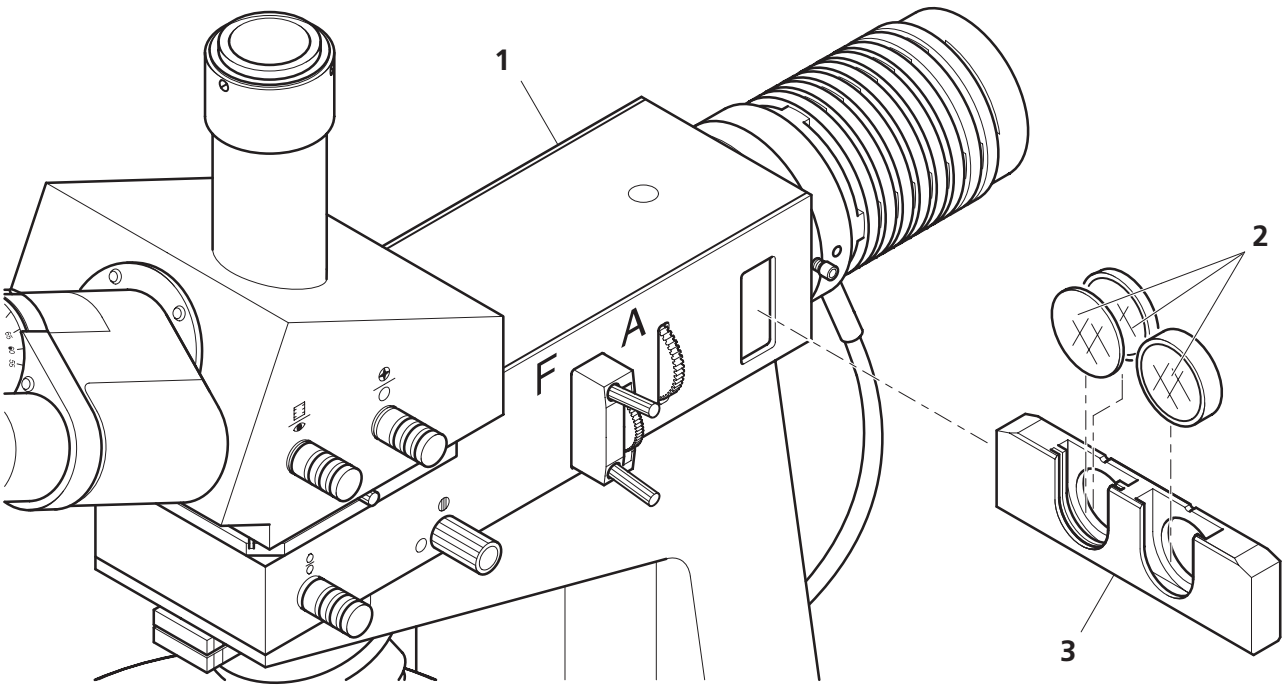


Figure 2-5 Fitting the filter slide

- Place the filters (2-5/2) suitable for the intended microscopy method in the filter slide (2-5/3), e.g.
  - attenuation filter 0.06 (6 % permeability)
  - attenuation filter 0.25 (25 % permeability)
  - conversion filter when a using a daylight colour film
  - narrow band interference filter, e.g. to increase contrast.
- Slide the equipped filter slide into the corresponding operating position in the tube (2-5/1).

NOTE Only use 32 mm filter diameter!

(6) Connecting to the mains

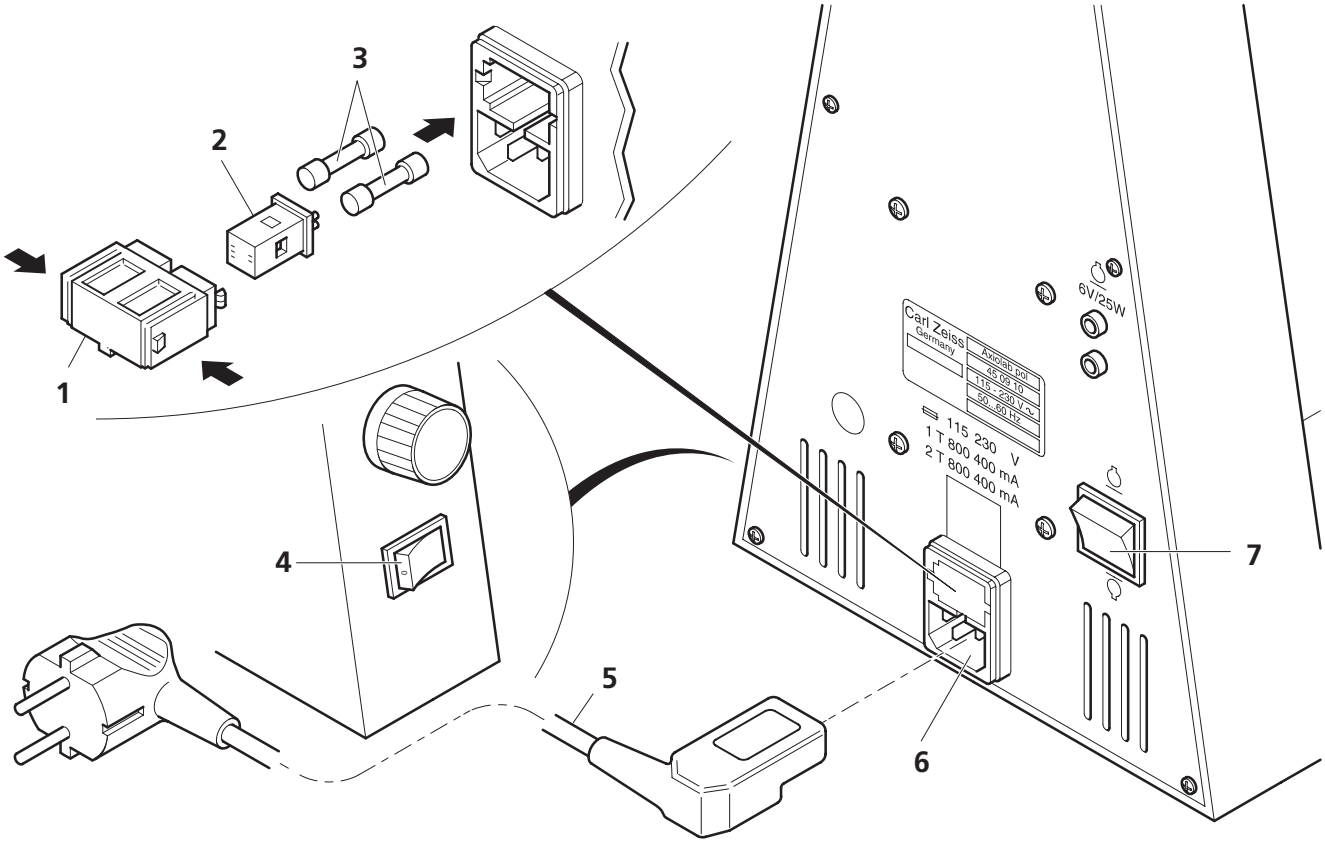


Figure 2-6 Connecting to the mains

IMPORTANT Check whether the voltage value indicated on the fuse holder agrees with the mains voltage!

- If necessary, remove the fuse holder (2-6/1) from the housing by simultaneously pressing the two spring tabs in the direction indicated by the arrows.

- Insert the fuse socket (2-6/2); the set voltage can then be viewed from the outside through a sight glass in the fuse holder (2-6/1).
  However, the use of suitable G-fuse links (5 x 20) mm (2-6/3) conforming to IEC 127 is a prerequisite for operation:
  for 230 V: 0.4 A / 250 V slow-blow
  for 115 V: 0.8 A / 250 V slow-blow

- Insert the mains cable (2-6/5) in the unit's power socket (2-6/6) and establish a connection to the mains.

(7) Switching on the unit

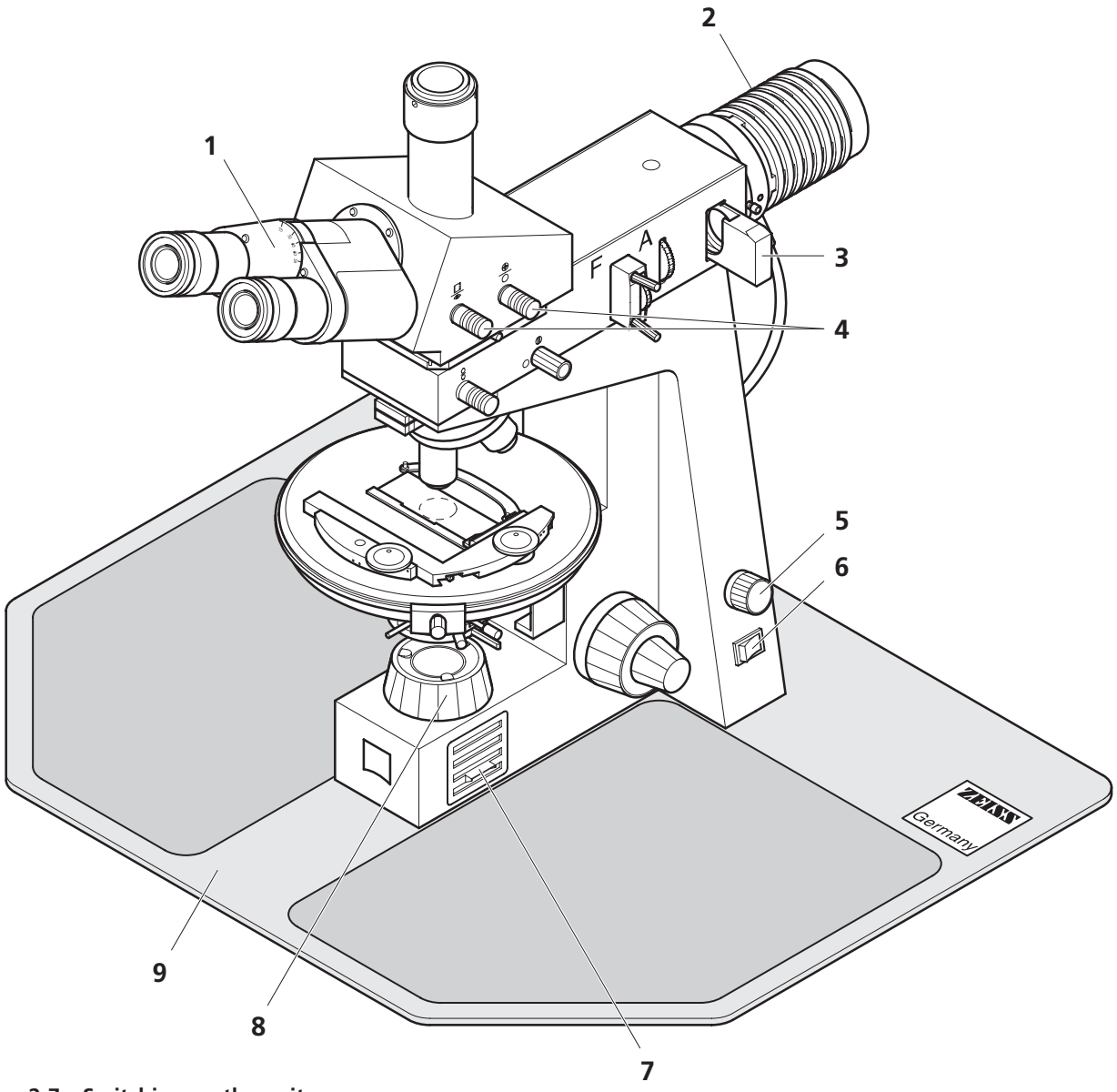


Figure 2-7 Switching on the unit

- Place the unit on the affiliated support (2-7/9).
- Switch on the unit by the On/Off switch (2-7/6).
  - The green mains pilot lamp in the knob of the switch must light up.

NOTE When the unit is off, the "0" marking is recognisable on the On/Off switch.

- Depending on the setting of the lighting changeover switch A/D (2-6/7), the lamp of the lighting unit (2-7/2) or (2-7/7) must light up.

  NOTE On the Axiolab Pol, the lighting changeover switch A/D (2-6/7) has the following functions:

  - Pressed in the top position - power supply of the lamp for reflected light
  - Pressed in the bottom position - power supply of the transmitted lighting unit

- Set the required brightness on the "Luminous intensity" control (2-7/5).

- Depending on requirements, place an attenuation or conversion filter for transmitted lighting on the light outlet opening of the luminous field diaphragm (2-7/8) or insert a filter for reflected lighting in the filter slide (2-7/3) and slide it into the beam path.

NOTE For **visual** operation, the push rods (2-7/4) must be pushed in. In this setting, 100 % of the light beam is applied to the binocular tube (2-7/1).

2.2 Commissioning

When commissioning the Axiolab Pol microscope for the first time, unpack the unit as described in Section 2.1 and set it up, connect it and prepare it for operation.

The Axiolab Pol microscope is delivered with lighting units that have been centred at the works. Even after a lamp replacement by the customer, there is no need to adjust the lighting.
If necessary, the stage height can be set to the top or bottom stop as required (see Section 2.7.1 (3)).

IMPORTANT For the transmitted light equipment 0.1, 0.2 and 0.4, the switch (2-6/7) must be pressed in the bottom position (symbol) for operation!

2.3 Lens selection

The lenses represent the core of the microscope. They may be marked as follows, for instance:

50x/0.80
∞/0.17

50x : the lens magnification factor
0.80 : the "numeric aperture"
∞ : infinite image distance
0.17 : calculated for covered specimens with a cover glass thickness of 0.17 mm
0 : calculated for uncovered specimens
– : cover glass-insensitive system that can be used equally for covered and uncovered specimens
Pol : the identification "Pol" or red lettering indicates that such systems are stress-free as the result of special technological treatment. The use of such optical systems is a prerequisite for optimum contrast in polarised light.

The lens magnification factor multiplied by the eyepiece magnification (in most cases 10x) results in the microscope's magnification factor: e.g. 50 x 10 = 500.

The numeric aperture x 1000, e.g. 0.80 x 1000 = 800, is the highest meaningful magnification factor; no further details of a specimen are visible beyond this value.

The designation "∞" signifies that such lenses cannot be used on microscopes whose lenses are marked with "160" instead.

Besides many others (see accessories), the following lenses are preferably available for the Axiolab Pol microscope:

in equipment described in Section 1.4

Lens designation		Colour marking	Free operating distance (FOD)	0.1	0.2	0.3	0.4	0.5
Plan-Neofluar 2.5 x / 0.075	Pol	brown	9.4 mm				x	x
CP-Achromat 5 x / 0.12	Pol	red	11.2 mm	x	x	x		
Epiplan 10 x / 0.20	Pol	yellow	18.4 mm	x	x	x	x	x
CP-Achromat 20 x / 0.40	Pol	green	0.50 mm	x	x		x	
CP-Achromat 50 x / 0.80	Pol	blue	0.40 mm		x	x	x	x
Epiplan 50 x / 0.70	Pol	blue	1.0 mm			x		x
Epiplan-Neofluar 20 x / 0.50	Pol	green	1.3 mm			x		x

2.4 Using the eyepieces

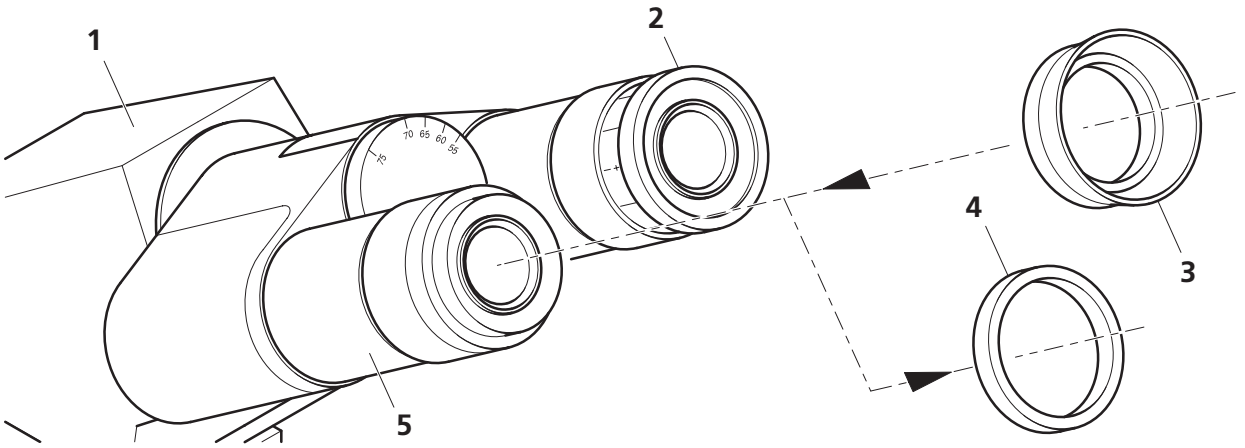


Figure 2-8 Using the eyepieces

The binocular tubes (2-8/1) used on the Axiolab Pol have two tubes of constant length. Owing to their constant length, at least one of the eyepieces must be a focusing eyepiece (foc.) to balance out visual acuity problems.

(1) Using the eyepieces E-Pl 10x/20 spec. (444231) with E-Pl 10x/20 spec. foc. (444232) (equipment 0.1)

Proceed as follows if the visual acuity of your eyes differs or when performing microscopy work without spectacles:

- Assign the non-adjustable eyepiece (e.g. 2-8/5) to your less myopic eye and focus on the specimen by means of the fine drive on the stand.
- Then, on the focusing eyepiece (2-8/2), adjust the sharpness for the other, more myopic eye until you can see the specimen equally with both eyes.

NOTE Spectacle wearers should preferably carry out microscopy work with their spectacles on.

(2) Using the eyepieces E-Pl 10x/20 spec. foc. Pol (44037) or E-Pl 10x/20 spec. foc. (444232) with reticule plates (equipment 0.2 and 0.5)

The eyepiece foc. Pol features an integrated reticule in an **oriented** position. When the eye distance has changed, both tubes turn synchronously so as to ensure that the positions of the orientation grooves (2-9/1) in the tubes remains unchanged. For correct use, the orientation screw (2-9/2) on the eyepiece must be inserted into one of the orientation grooves. This guarantees that the cross always exactly marks the oscillation direction of the polarisers.

When using the eyepiece Pol (2-9/4) or when using an eyepiece with reticule and format plates (2-9/6)), two focusing eyepieces are needed. The slight displacement of the image caused by reticule or format plates is compensated on the dioptre scale of the E-Pl 10x/20 spec. foc. by virtue of the fact that the zero position is not indicated by the white dot (W), but by the red dot (R).

- The manufacturer has stuck the reticule or format plates (2-9/6) into the screw-in holder (2-9/5), thus enabling easy replacement by the customer.
- To replace or insert such plates, only the screw-in holders need to be replaced.

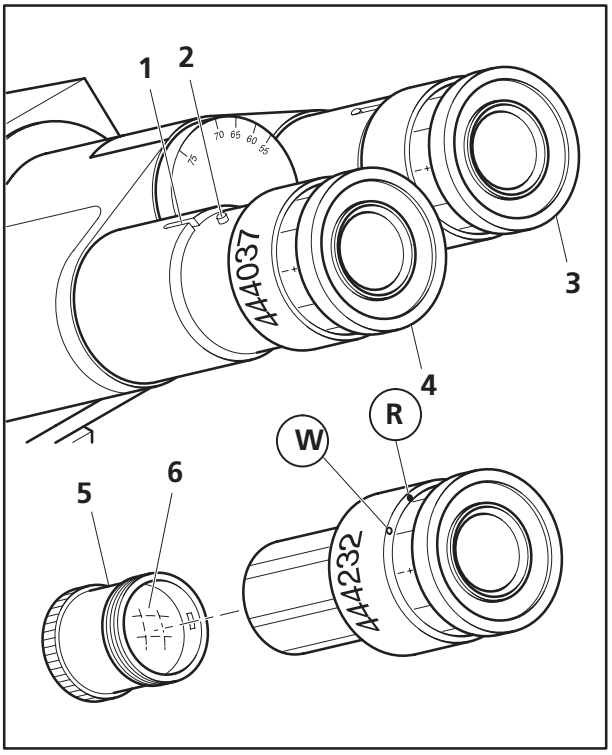


Figure 2-9 Using the eyepieces Pol or with reticule plates

When using either eyepiece type, proceed as follows to arrive at a correct adjustment:

- Assign the eyepiece with the reticule or format plate to the less myopic eye.
- Adjust the eye lens of this eyepiece until the cross or the figure on the plate is sharply focused.
- By means of the fine drive on the stand, then focus onto the specimen for this eyepiece connection.
  Then readjust the focus for the other, more myopic eye on the second focusing eyepiece via the eye lens (2-9/3) until you can see the specimen equally with both eyes.

NOTE For low-light contrast methods or generally weakly anisotropic specimens, it is advisable to replace the standard rubber rings (2-8/4) by the fold-over eye cups (2-8/3) from the accessories (444801) to shield off disturbing ambient light.

(3) Aligning the eyepiece E-Pl 10x/20 spec. foc (444232) with the reticule micrometer 14 : 140 (454060)

Alignment of the reticule micrometer according to the oscillation direction of the polariser (e.g. for the application in Section 4.1.3 (2)) requires the following procedure:

Prerequisite

- Basic settings as described in Sections 2.6.1 and 2.6.2 up to Item (3),
- 5x or 10x lens magnification and
- the adjustment specimen Pol (453679).
- Bright field: Focus on the longitudinal side of the adjustment specimen and optimise the contrast (handling: 2-12/5).
- Move the vertical eyepiece line until it is precisely flush with the longitudinal edge.
- Switch on the polariser (2-13/4) and analyser (2-13/5 or 3), adjust the "Luminous intensity" control (2-7/5) to 6 V and adjust the aperture diaphragm (2-12/5) to approx. 0.3.
- Turn the specimen stage (2-11/3) until the specimen is dimmed completely.
- Switch off the analyser (2-13/5 or 3) and **turn the eyepiece** until the eyepiece line and the longitudinal edge are once again precisely flush or are parallel.

IMPORTANT The tube 35°/20 (equipment 0.1) **does not feature any** reticule slaving and so **this adjustment must be repeated whenever the eye distance changes!**

2.5 Meanings of the symbols on the tube

In line with the main application of the unit (observing specimens in polarised transmitted light), the positions of the operator controls have been conceived so as to ensure that all push rods are **pushed in**.

The individual operator controls are identified by the following symbols:

= affiliated push rod pulled for reflected lighting

= affiliated push rod pushed in for transmitted lighting

= affiliated push rod pulled to use the photo output

= affiliated push rod pushed in for specimen observation through the binocular look-in assembly

= affiliated push rod pulled to observe interference phenomena (conoscopy)

= affiliated push rod pushed in for direct specimen observation

= white marking of the rotary element points to this symbol; reflected light polariser off

= white marking of the rotary element points to this symbol; reflected light polariser on

= reflected light aperture setting for optimum contrast (see Sections 2.6.3 (2) and 2.6.4 (3))

F = field diaphragm, also luminous field diaphragm, reflected light

A = aperture diaphragm, reflected light

Therefore, the following applies to the arrangement of the symbol: symbol for the push rod!

2.6 Illumination and contrast methods

2.6.1 Transmitted light bright field

(1) Setting the unit for transmitted light bright field observation

Depending on the chosen equipment, the following settings (Figure 2-10) must be made for transmitted light bright field observation.

IMPORTANT The operator controls listed below are only available on the tube variants marked (X) and can therefore also only be operated there!

Equipment according to Section 1.4 (1)

Checks and settings (X) for the available equipment 0.1 to 0.5	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**
1. Switch on the lighting (2-10/8). Set the lighting changeover switch (2-6/7) to transmitted light (set the switch to the bottom position).	X	X	X	X	X
2. The dust protection slides (2-10/19) must be pushed in completely.	X	X	X	X	X
3. Switch off the analyser; to do this, pull out the push rod (2-10/21) to the latch.		X	X	X	X
4. The BERTRAND lens push rod (2-10/2) must be pushed in.		X	X	X	X
5. The plane glass push rod (2-10/5) must be pushed in.			X		X
6. The photo output push rod (2-10/4) must be pushed in.				X	X
7. Swivel out the polariser D, rotating (2-10/11).				X	X
8. Swivel out the polariser, swivelling (2-10/13).	X	X	X		

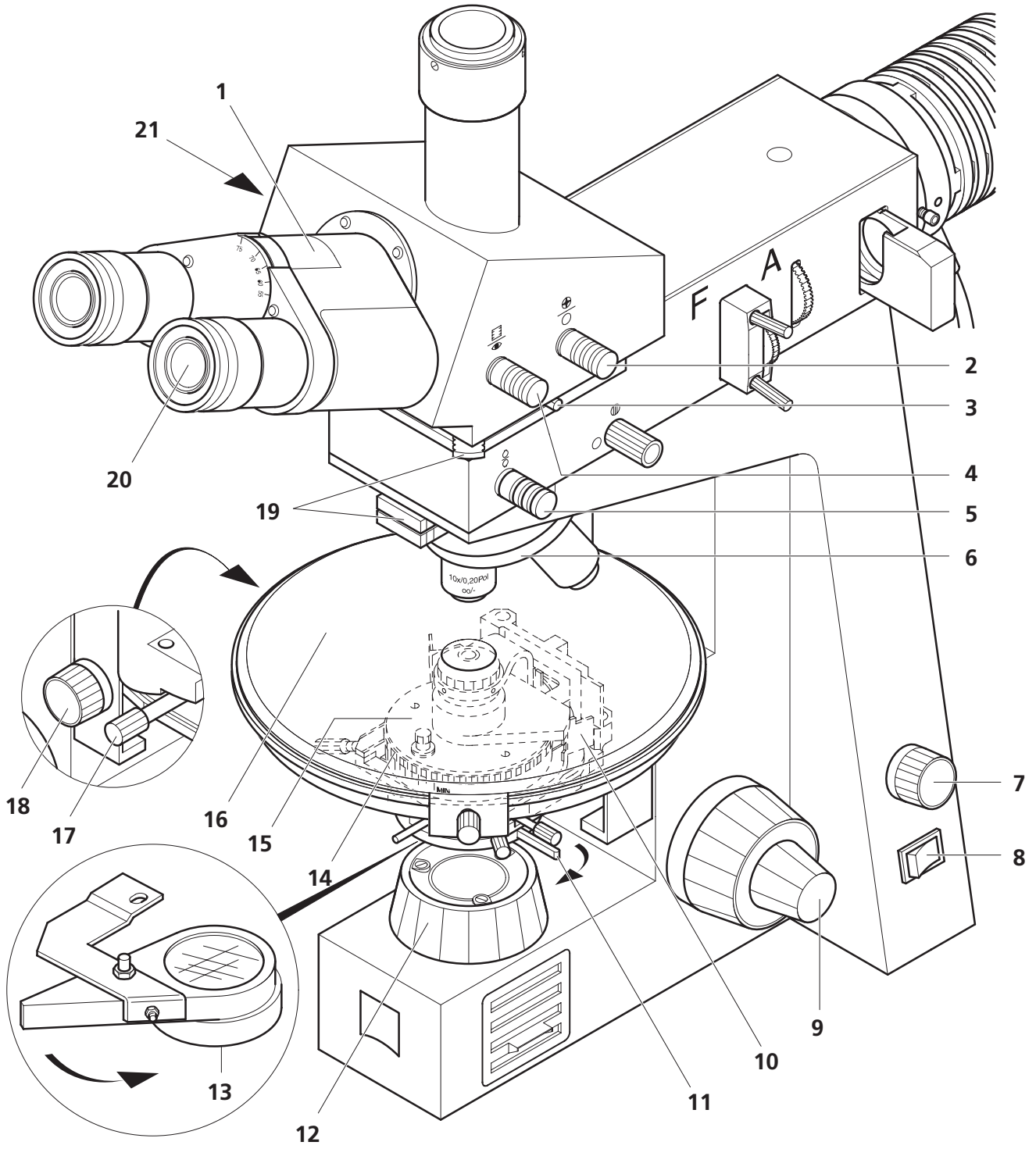


Figure 2-10 Working with transmitted light

- Reduce the lamp voltage (2-10/7) to approx. 2 ... 3 V.
- Place a transmitted light specimen rich in contrast with its specimen carrier side (thicker glass) onto the specimen stage (2-10/16).
- Swivel in the 10x lens (yellow marking ring) on the lens turret (2-10/6).
- Check the zero settings on the eyepiece scale (2-10/20) (as described in Section 2.4 (2), adjust the zero mark over the white or red dot).
- Open the luminous field diaphragm (2-10/12) and the aperture diaphragm (2-10/14) (turning clockwise results in the maximum aperture).
- By means of the drive knob (2-10/18), move the condenser (2-10/15) close to the top stop (if the condenser has a front optical system that swivels out, switch it off by means of the controls (2-10/10 or 17)).
- When looking into the binocular tube (2-10/1), a bright circle (the eyepiece diaphragm) can be recognised with each eye. The circles unite to one circle when the two eyepiece connections are adjusted to the right eye distance.
- Sharply focus the specimen by actuating the fine and coarse drive (2-10/9).

NOTE The settings described in Section 2.4 to compensate for myopia and the adjustments to the reticule must be carried out if there differences in the visual acuity of your two eyes, when working without spectacles and when using the eyepiece Pol (444037).

(2) Centring the lenses

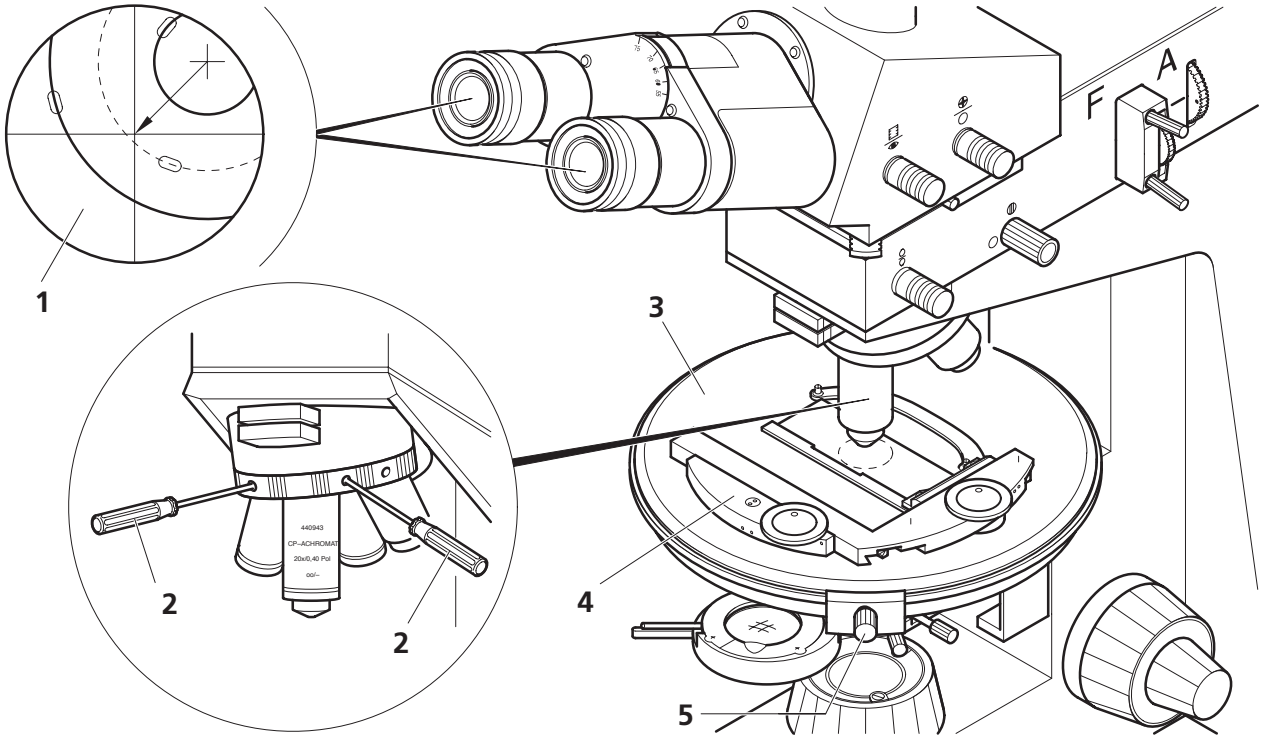


Figure 2-11 Centring the lenses

When turning the stage Pol (2-11/3) and when lenses are not centred, details of the specimen wander beyond the middle of the eyepiece cross on circular paths (2-11/1 – dashed line). Carry out the following steps to centre the lenses:

- Undo the specimen stage latch by turning the screw (2-11/5) by approx. 1/4 turn in counter-clockwise direction.
- Activate a transmitted light lens with a medium magnification factor (20x - 50x) on the lens turret.
- Insert the (small) key, a/f 1.5 (2-11/2) in the centring holes on the lens turret.
- Turn the specimen stage and search for the apparent centre of rotation (cross (2-11/1)). The centre of rotation is simultaneously the centre of rotation of the stage.
- Using the keys, move this centre of rotation to the intersecting point of the eyepiece reticule (equipment 0.2 to 0.5) and thus into the optical axis of the microscope.
- Repeat the operation with a distinct, small detail of the specimen in the direct proximity of the middle of the rotary stage.
- Carefully extract the keys.
- Activate the neighbouring lens; search for the centre of rotation or the distinct detail of the specimen and carry out adjustment as described above.

NOTE To achieve centring, it is mandatory that the lenses be changed only by touching the knurled edge of the lens turret.

(3) Adjusting the condenser – KÖHLER lighting principle

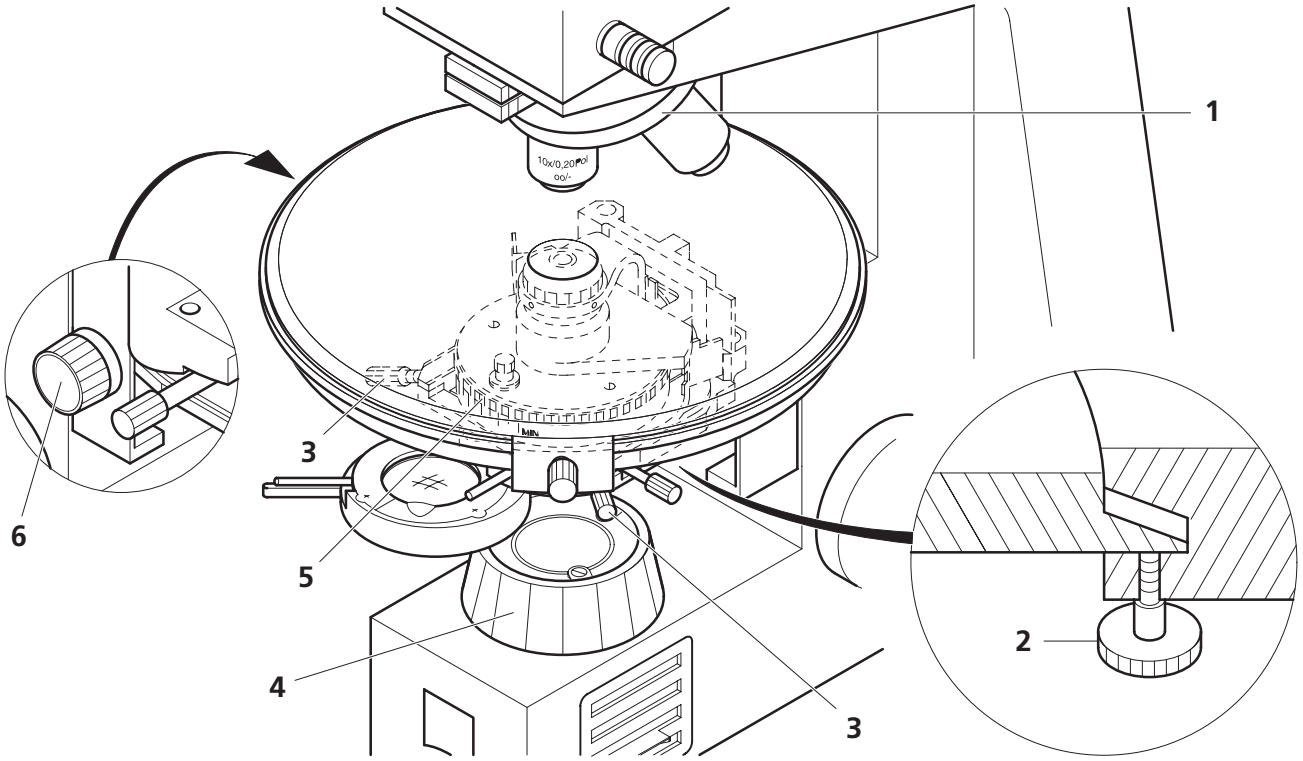


Figure 2-12 KÖHLER lighting

- Activate the 10x lens by turning the lens turret (2-12/1). Sharply focus the specimen.
- Close the aperture diaphragm (2-12/5) to half the diameter (middle position).
- Close the luminous field diaphragm (2-12/4) by turning to the left and move the drive knob (2-12/6) until the diaphragm image appears sharply focused.
- By actuating the centring screws (2-12/3), centrically move the diaphragm image to the middle of the field of vision.
- Turn the screw for the condenser height stop (2-12/2) on the condenser mount (bottom right) until it is at the top.
- Open the luminous field diaphragm until your image just disappears out of the field of vision.
- Depending on the respective specimen and lens, the contrast is controlled by the aperture diaphragm (2-12/5).

NOTE The aperture diaphragm **does not** serve to control image brightness! (Loss of image quality.) Approx. **2/3 of the lens aperture** should be illuminated.
Check the degree of dimming on the rear lens of the lens system; to do this, you may have to remove one eyepiece from the connection piece.
When changing the lens, the specimen field that can be observed and the lens aperture also change, with the result that the latter-mentioned diaphragm settings should be repeated.

2.6.2 Transmitted light polarisation

(1) Setting the unit for transmitted light polarisation

The settings described in the Section entitled "Transmitted light bright field" are a prerequisite for this method.

Carry out the following:

- Set the unit as described in Section 2.6.1 (1), corresponding to the available equipment.
- Adjust the lens as described in Section 2.6.1 (2).
- Set the lighting according to KÖHLER, Section 2.6.1 (3).

(2) Switching on / aligning the analyser

Depending on the equipment, the arrangement and adjustment of the analyser differs slightly.

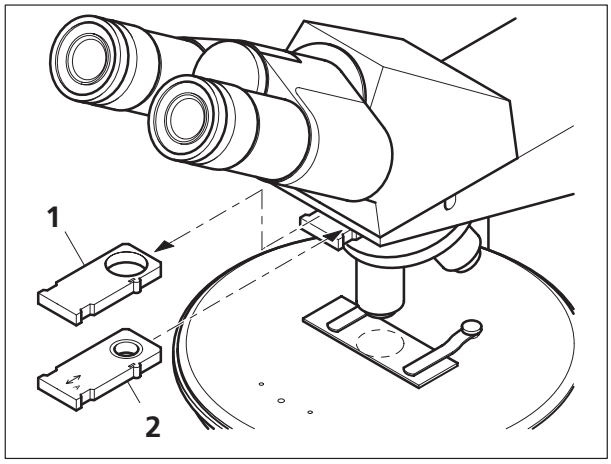


Figure 2-13 Analyser (equipment 0.2)

Equipment 0.1

The analyser is in the analyser slide (453687). The analyser's direction of oscillation is fixed at the works to the NORTH-SOUTH direction.

- After removing the dust protection slide (2-13/1), slide the analyser slide (2-13/2) fully into the top slit of the lens turret.

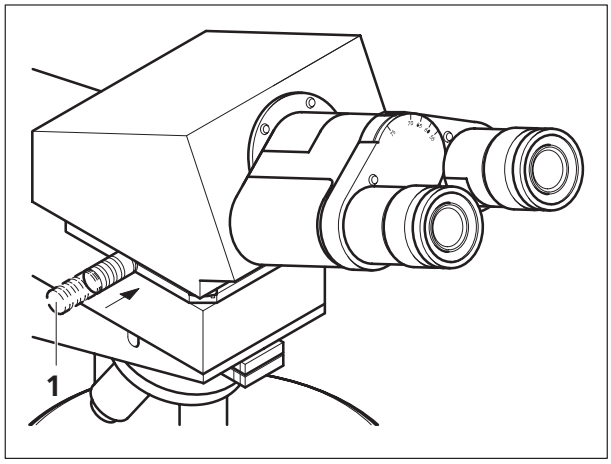


Figure 2-14 Analyser (equipment 0.2)

Equipment 0.2

The analyser is integrated in the binocular tube Pol. The analyser's direction of oscillation is fixed at the works to the NORTH-SOUTH direction.

- Move the analyser into the beam path by pushing in the push rod (2-14/1) on the tube.

Equipment 0.3 to 0.5

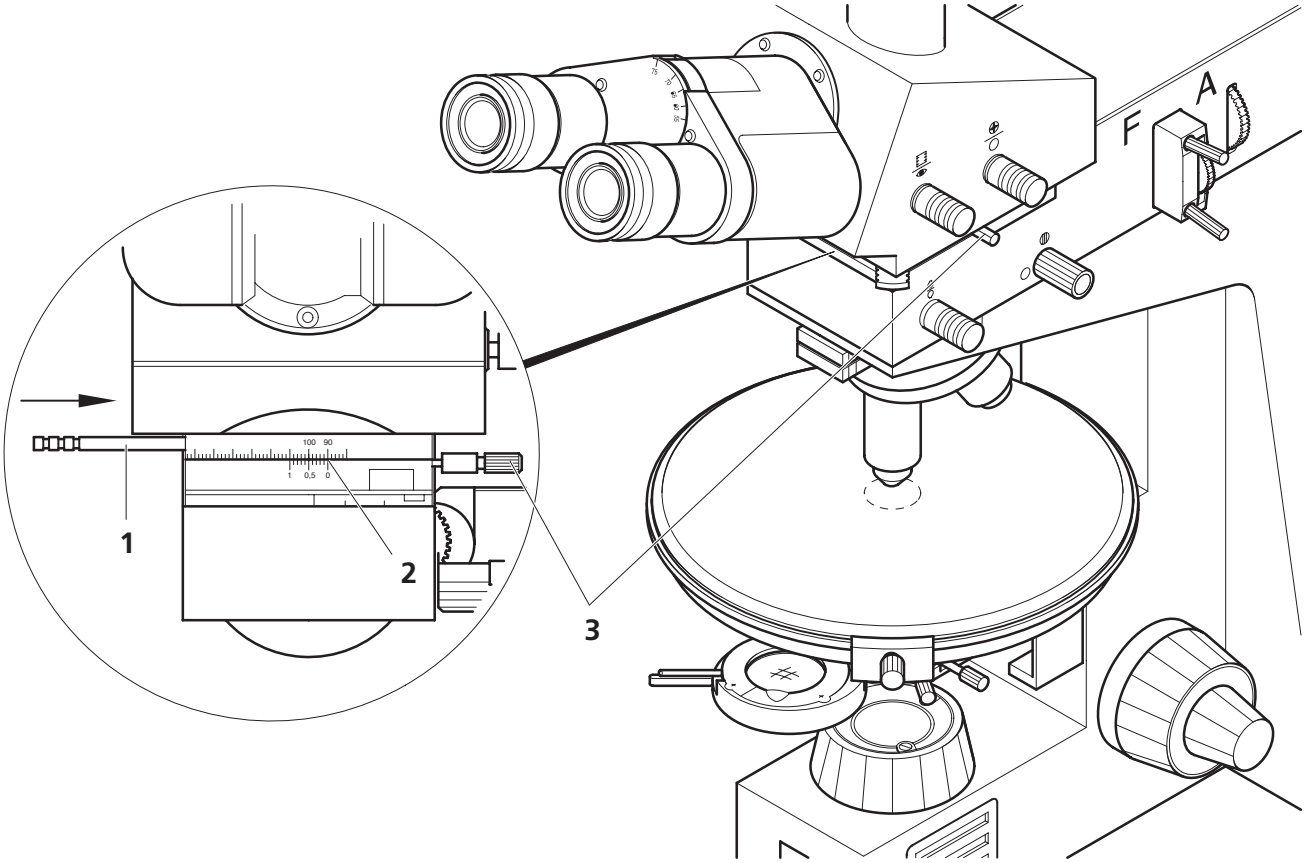


Figure 2-15 Analyser (equipment 0.3 – 0.5)

The analyser is integrated in the binocular tube Pol and can be rotated by 180°. In the 90° position, the analyser's direction of oscillation is fixed at the works to the NORTH-SOUTH direction.

- Cancel fixing of the analyser by undoing the clamping screw (2-15/3).
- Turn the analyser on the push rod (2-15/1) until the 90° analyser division marking is aligned **exactly** to the vernier scale (2-15/2).
- In this position, tighten the clamping screw (2-15/3) again.
- Move the analyser into the beam path by **pushing** in the push rod (2-15/1).

(3) Switching on / aligning the polariser

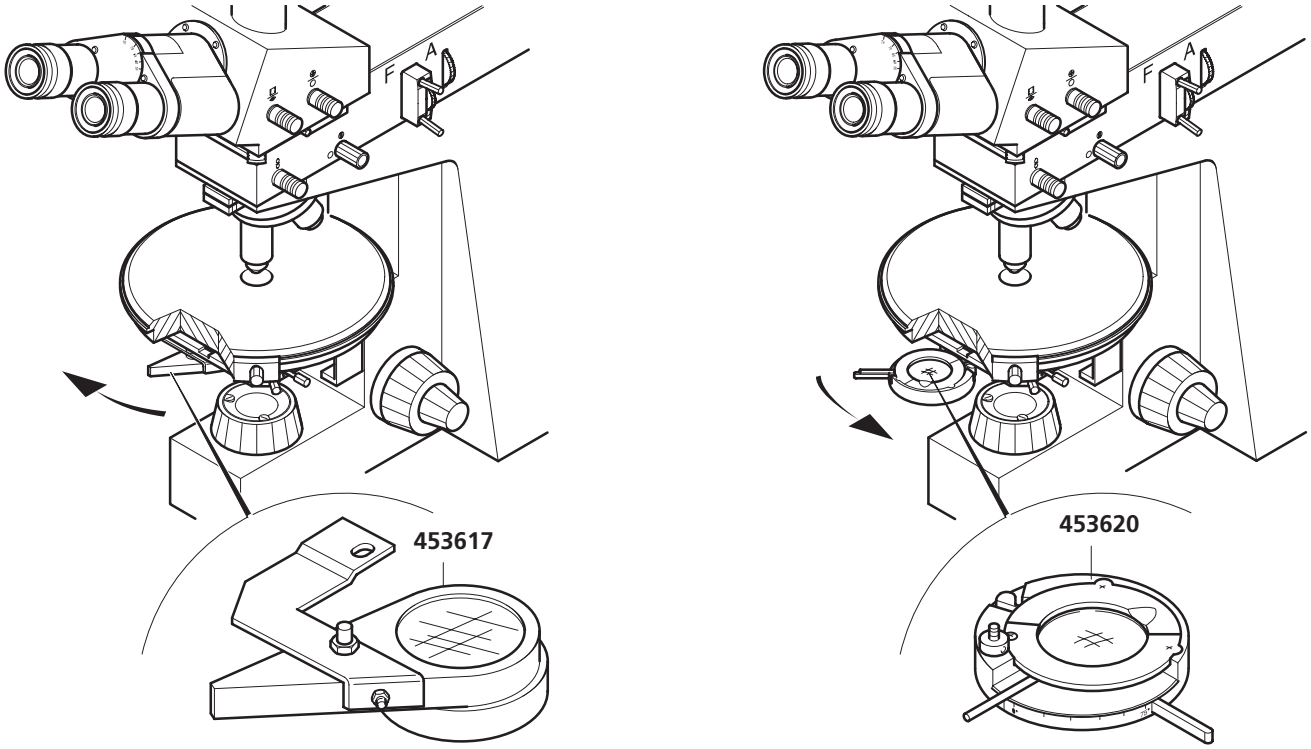


Figure 2-16 Polariser variants

The polariser is located underneath the condenser. Depending on the equipment, one of two polariser variants is used:

Swivelling polariser (453617) with the orientation of the direction of oscillation fixed at the works to the EAST-WEST direction.
This polariser is simply swivelled in fully (the lever then points to the front).

Polariser D, rotating (453620) with the oscillation direction oriented to the EAST-WEST direction in the zero engaging position. This polariser is swivelled in and engaged (the swivel lever then points to the right).

The rod on the pivoting bearing must be engaged in the 0° engaging position (rod points to the front)!

With this setting, the oscillation directions of the analyser and polariser are exactly below 90°, and we speak of "crossed polars".

- Set the "luminous intensity" control to approx. 6 V.

When looking through the eyepiece without a specimen, you see a dimmed field of vision. Anisotropic specimens, however, exhibit periodic brightening or interference colours when the specimen stage is rotated.

NOTE For a specimen image rich in contrast, reduce the illumination aperture to 0.15 – 0.20 as from approx. 20x, i.e. close the aperture diaphragm accordingly.

(4) Conoscopy (equipment 0.2 to 0.5)

The interference phenomena that a detail of the specimen produces in the rear focal plane of transmitted light lenses is frequently used for material diagnosis. (See Section 3.1.3 (6) and (7)) for further details of this method.)

The settings described in the section on transmitted light bright field (Section 2.6.1) and polarisation as described in Section 2.6.2 (1) to (3) are a prerequisite, particular attention being paid to **precise** centring of the lens and **exact** KÖHLER lighting.

To observe the interference phenomena, it is necessary to use a lens with a high numeric aperture. Particularly the following lenses are suitable:

PC-Achromat 50x/0.80 ∞/0.17 Pol	440953
Plan-Neofluar 100x/1.30 ∞/0.17 Oil Pol	440483
Achromat UD 50x/0.60 ∞/S Pol	442005

- View the detail of the specimen to be examined with one of the above-mentioned lenses and move it exactly over the reticule in the eyepiece Pol (444037).

NOTE The lens must be centred so exactly that the detail of the specimen will not move out of the middle when turning the stage.

- A fixed-focus BERTRAND lens serves to observe the rear focal plane of the lens. It becomes active when the control (2-17/1) – ⊕ – is pulled.

- Simultaneously with the BERTRAND lens, a pin diaphragm is switched into the beam path to shield off against interference from neighbouring lenses.

NOTE This diaphragm has an indirect effect, i.e. it is not visible by viewing through the eyepiece.

IMPORTANT To observe the complete focal plane of the lens, the aperture diaphragm (2-17/4) must be opened fully and, when using the Plan-Neofluar 100x/1.30 Oil Pol, the front optical system 1.4 (445332) must be used.
When using the condenser 0.9 Z (445212), the luminous field diaphragm (2-17/3) must also be opened to such an extent that the focal plane of the lens appears without truncation.

- When the analyser push rod is **pulled**, the circular focal plane of the lens is now visible in the eyepiece.
  When the analyser push rod is **pushed** in and the polariser is aligned as described in Section 2.6.2, an extinction cross is recognisable in the focal plane of the lens without a specimen or, with a specimen, interference figures may be recognisable.

- For conoscopy with monochromatic light, place narrow band filters (260201...) onto the light outlet opening at (2-17/3).

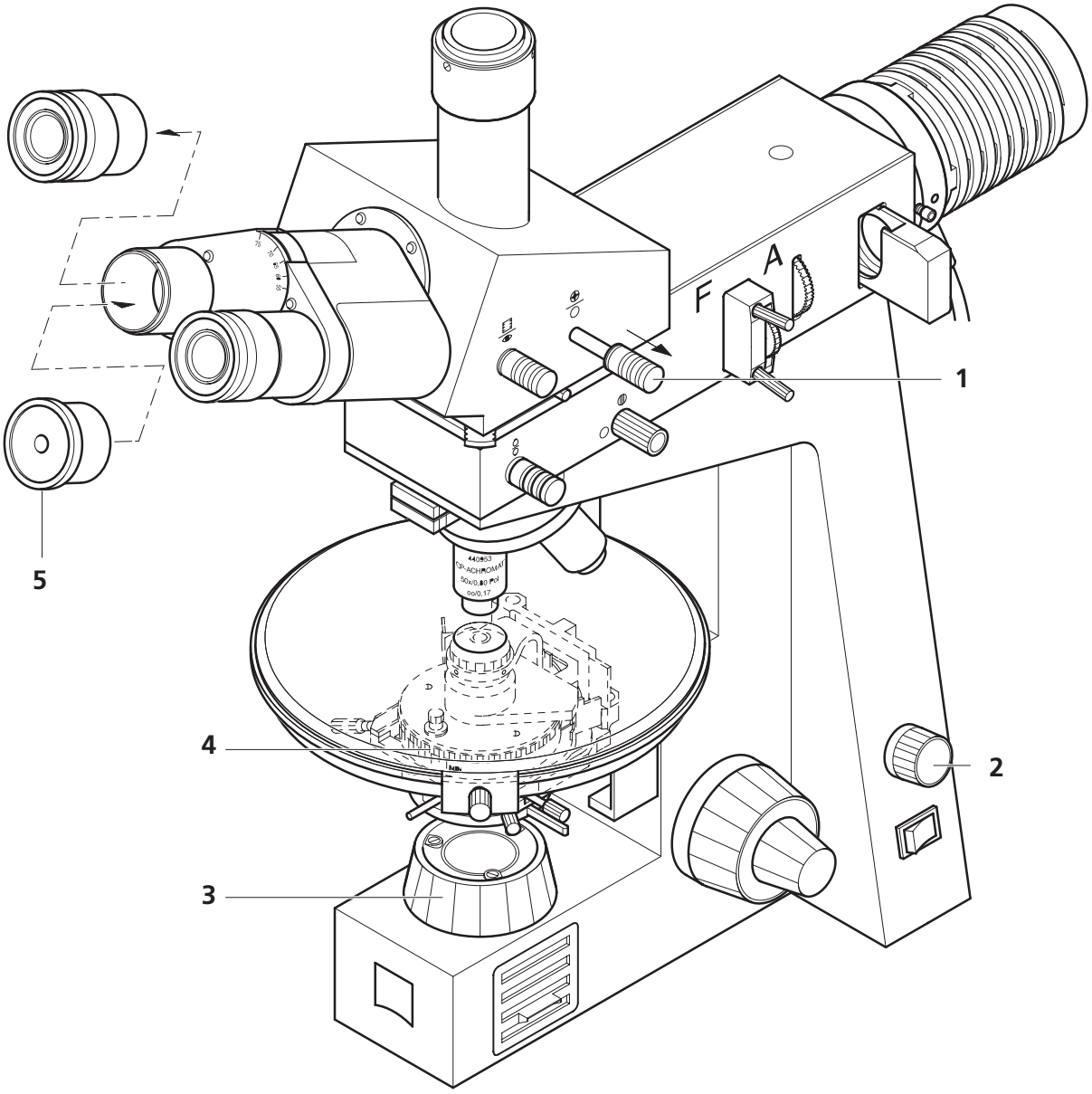


Figure 2-17 Conoscopy

- The maximum light output of the lamp is required for conoscopy, i.e. the "Luminous intensity" control (2-17/2) must be turned fully (6 V).

NOTE On particularly small specimen details, disturbing interferences from neighbouring specimens can be excluded effectively by slightly lowering the specimen stage (move the fine drive forward, in counter-clockwise direction by approx. 20 µm).

- When using the equipment 0.1, the dioptre (accessory 444020) can be used. To do this, remove an eyepiece from the binocular tube and insert the dioptre (2-17/5) here.

2.6.3 Reflected light bright field (for equipment 0.3 and 0.5 only – Axiolab Pol with reflected lighting)

(1) Setting the unit for reflected light bright field observation

The following basic settings must be made for reflected light bright field observation:

- Switch on the lighting (2-18/7).
- Set the lighting changeover switch (2-6/7) to **reflected light** (switch in the top position).
- Dust protection slides (2-18/8) must be **pushed in** fully.
- The filter slide (2-18/1) must be in **an engaged position**.
- **Pull out** the push rod for reflected lighting with the " ⏢ " symbol (plane glass beam splitter (2-18/6))
- The BERTRAND lens push rod (2-18/3) must be **pushed in**.
- Push in the luminous field diaphragm slide (2-18/2) **until it engages.**
- **Switch off the reflected light polariser;** to do this, move the switch lever (2-18/4) to the front so that the white line points to the "◯" symbol.
- For observation, the photo output push rod (2-18/5) must be **pushed in**.
- Switch off the analyser; to do this, pull out the push rod (2-18/10) until it engages.

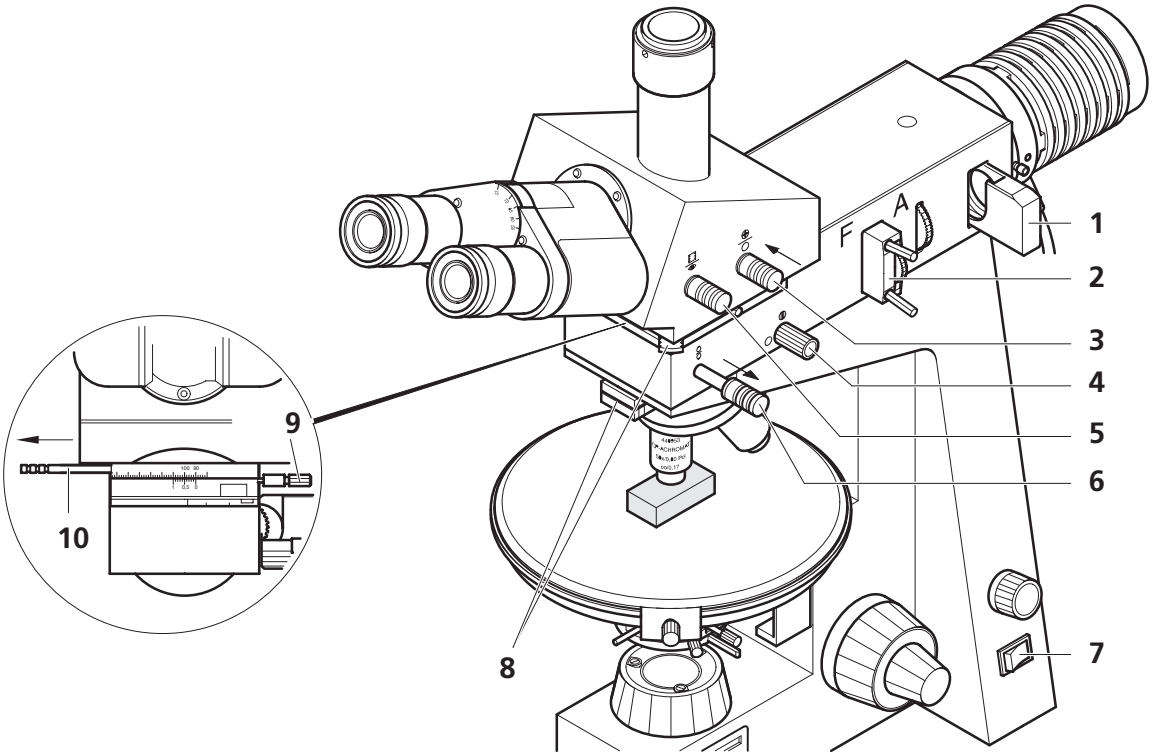


Figure 2-18 Basic settings for reflected light

(2) KÖHLER lighting in reflected light

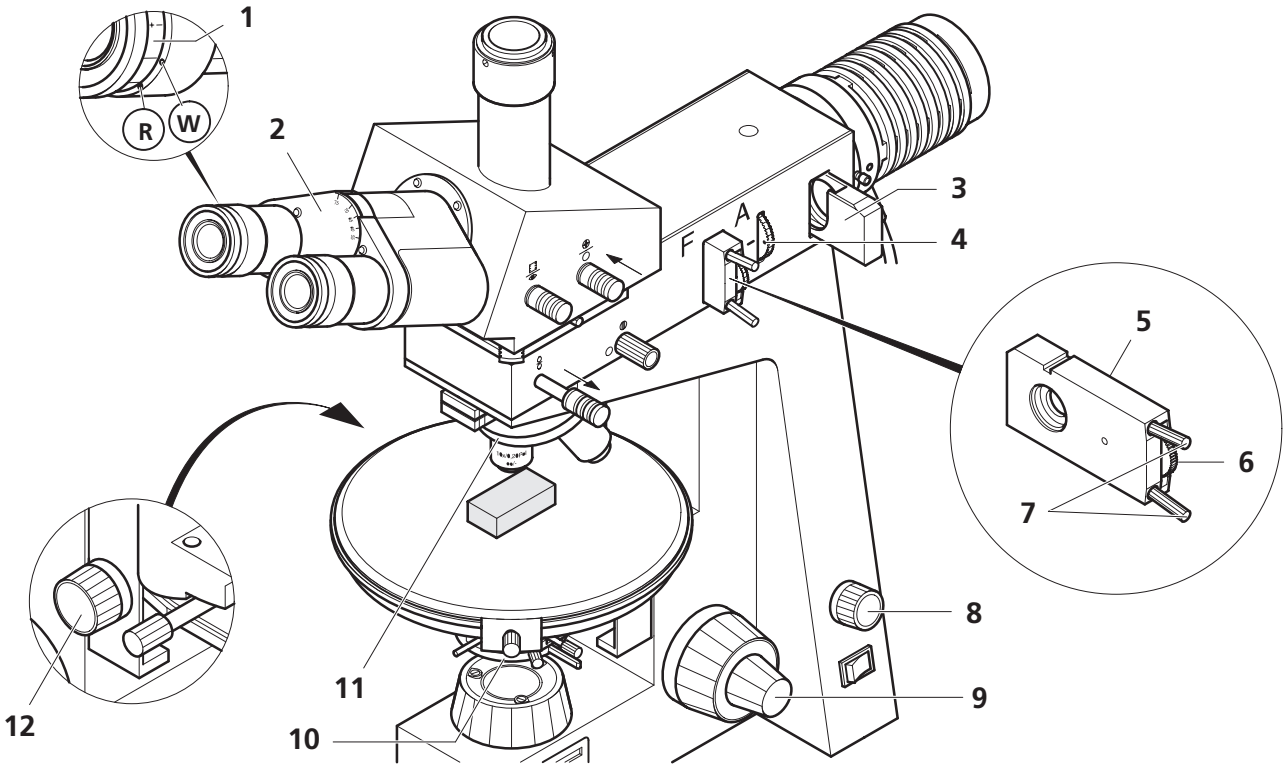


Figure 2-19 Working in reflected light

- Set the "Luminous intensity" control (2-19/8) to approx. 2 ... 3 V.

- Place a reflected light specimen rich in contrast (ground specimen) onto the rotary stage, if necessary, lower the rotary stage with the coarse drive (2-19/9) according to the height of the specimen and, if necessary, lower the stage carrier (see Section 2.7.1 (3)).

IMPORTANT Make absolutely sure that the polariser for transmitted light observation (2-19/10) is moved upward fully by means of the condenser drive (2-19/12), thus avoiding collision with the luminous field diaphragm!

NOTE The surface of the specimen must be exactly perpendicular to the reflected lighting system; if necessary, align the specimen surface with a grind press (accessory 478962).

- Swivel in the 10x lens (yellow marking ring) on the lens turret (2-19/11).

- Check the 0 settings on the eyepiece scale (2-19/1) as described in Section 2.4 (adjust the 0 mark over the white or red dot).

- Close the aperture diaphragm (2-19/4) approximately halfway by turning the setting wheel in the downward direction.
- Open the luminous field diaphragm completely by turning the setting wheel (2-19/6) in the upward direction.
- When viewing into the binocular tube (2-19/2), a bright circle (the eyepiece diaphragm) can be recognised with each eye. The circles united to one circle when the two eyepiece connections are set to the right eye distance.
- Completely close the luminous field diaphragm by turning the setting wheel (2-19/6) in the downward direction.
- Adjust the coarse and fine drive (2-19/9) until the diaphragm that becomes visible in the field of vision is sharply imaged.
- Move the diaphragm image to the middle of the field of vision by actuating the centring screws (2-19/7).
- Open the luminous field diaphragm until the diaphragm just reached beyond the edge of the field of vision.
- When the diaphragm is imaged, the surface of the specimen is also clearly imaged. If necessary, slightly correct the adjustment to the specimen plane by actuating the fine drive (2-19/9).
- Regulate the brightness of the image by means of the "Luminous intensity" control (2-19/8) and use the corresponding attenuation filter (467848 / 49) in the filter slide (2-19/3).

NOTE Do not forget the settings described in Section 2.4 if the visual acuity of your eyes differs, when working without spectacles or when using the eyepiece Pol (444037) or an eyepiece foc.!

NOTE Now, depending on the specimen, control the contrast by means of the aperture diaphragm (2-19/4). The aperture diaphragm does not serve to control image brightness! (Loss of image quality.) Approx. 2/3 of the lens aperture should be illuminated.

Check the degree of dimming on the rear lens of the lens system. To do this, pull one eyepiece out of the connection piece.

When the lens is changed, the specimen field that can be observed and the lens aperture also change, with the result that the latter-mentioned diaphragm settings should be repeated.

(3) Centring the lenses

The reflected light lenses are centred analogously to the description in the transmitted light bright field section (Section 2.6.1 (2)).

2.6.4 Reflected light polarisation (for equipment 0.3 and 0.5 only – Axiolab Pol with reflected lighting)

(1) Unit settings for reflected light polarisation

The settings described in the reflected light bright field section are a prerequisite for use of this method.

Carry out the following:

- Depending on the available equipment, the unit settings described in Section 2.6.3 (1).
- Lighting according to KÖHLER, Section 2.6.3 (2).
- Lens adjustment as described in Section 2.6.3 (3).

(2) Switching on / aligning the analyser

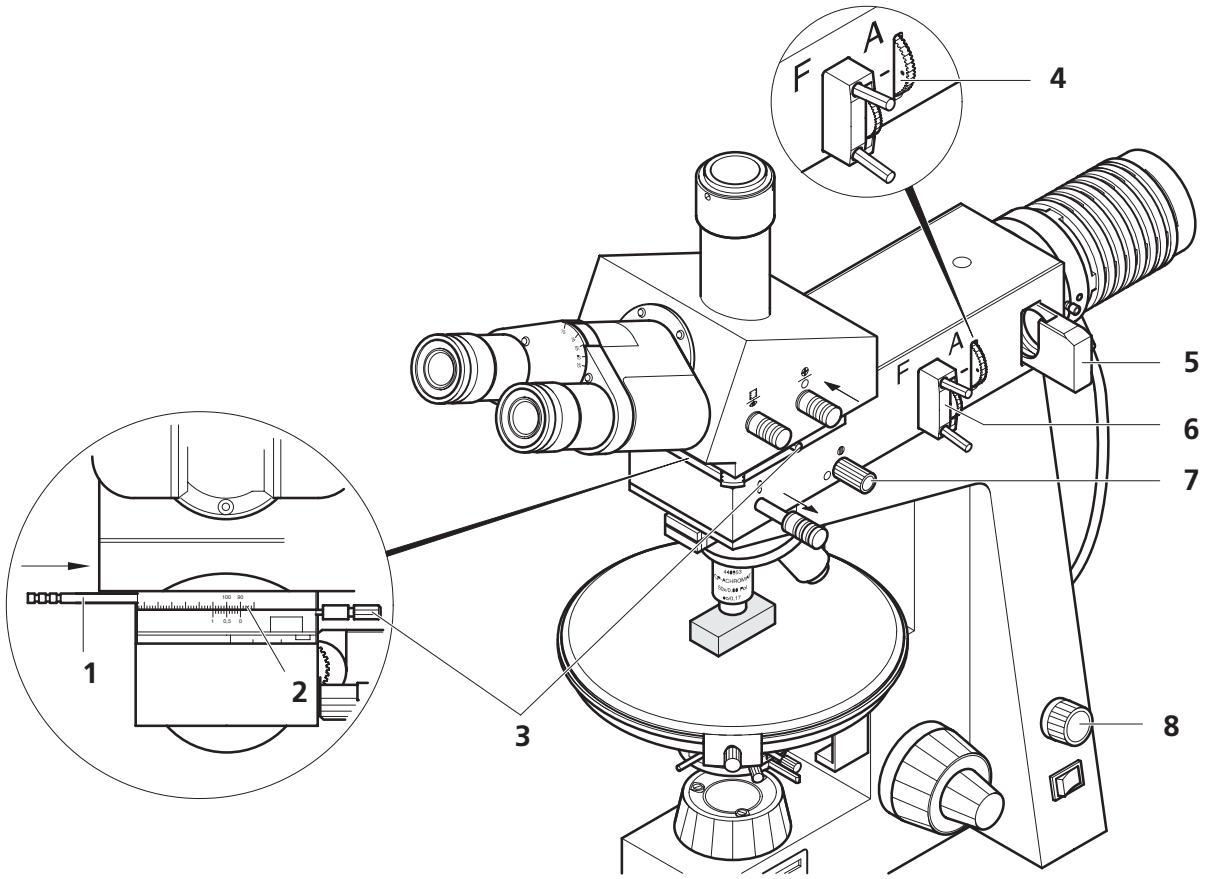


Figure 2-20 Analyser settings for reflected light

The analyser is integrated in the binocular tube Pol and can be rotated by 180°. The analyser's oscillation direction is orientated at the works to the NORTH-SOUTH direction, when **in the 90° position**.

NOTE The following settings can be ignored if you have already been working with transmitted light polarisation and the analyser is aligned as described in Section 2.6.2 (2).

- Cancel fixing of the analyser by turning the clamping screw (2-20/3).
- Turn the analyser by the push rod (2-20/1) until the 90° analyser division marking is aligned **exactly** to the vernier scale (2-20/2).
- Tighten the clamping screw (2-20/3) again in this position.
- Move the analyser into the beam path by pushing in the push rod (2-20/1).

(3) Switching on the polariser / reflected light

The oscillation direction of the reflected light polariser is fixed at the works to the EAST-WEST direction.

- The reflected light polariser is activated by turning the knob (2-20/7) in the upward direction. In doing so, the orientation line points to the "⊜" symbol.
- By means of the "Luminous intensity" control (2-20/8), adjust the lamp voltage to a rated voltage of 6 V (end position) and move any attenuation filters in the slide (2-20/5) out of the beam path.

When the analyser is in the 90° setting (crossed polarisers), an isotropic image viewed through the eyepiece is maximally dimmed.

NOTE The basic settings of the polarisers described in (2) and (3) are also the prerequisite for use of the Antiflex cap (accessory 444922) belonging the Plan-Neofluar 2.5x/0.075. It is advisable for enhancing contrast and reducing reflections when viewing low-reflection specimens in the reflected light bright field.
This cap is fitted into the front optics of the lens and is turned until maximum brightening is achieved.
In certain circumstances, closing the luminous field diaphragm (2-20/6) is a further possibility of increasing contrast.

NOTE As from a lens magnification of 20x, the lighting aperture must be reduced to approx. 0.20 for images rich in contrast in natural anisotropic colours! To do this, close the aperture diaphragm (2-20/4) accordingly by turning the setting wheel in the downward direction.
As an aid to orientation, there is a marking on the setting wheel and a line on the stand.
If both markings are at the same level, the best polarisation-optical contrast has been achieved for the Epiplan 50x/0.70 Pol lens. For the Epiplan 100x/0.90 Pol or 100x/1.30 Oil Pol, the aperture diaphragm is closed completely. The aperture diaphragm can be left completely open for lens magnifications from 2.5x to approx. 10x.

2.7 Using and replacing the modules

2.7.1 Rotary stage Pol

(1) Specimen mount

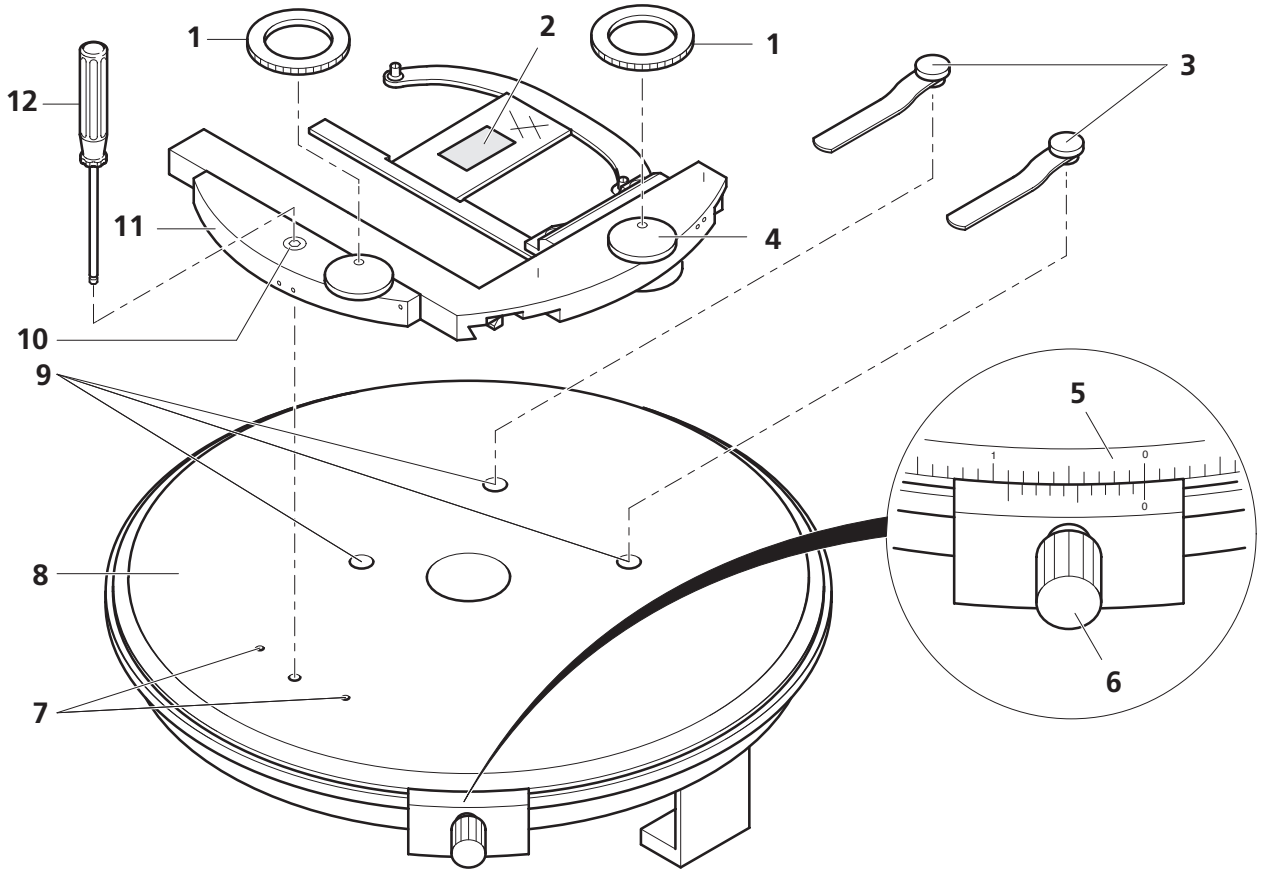


Figure 2-21 Specimen mount / latch

The included stage springs (2-21/3) serve to mount the specimen on the rotary stage (2-21/8) . They are inserted in two of the three holes (2-21/9) and, depending on the size of the specimen carrier or the scan area, they are placed diagonally, opposite each other or in parallel.
The specimen guide Pol (2-21/11) (accessory 473325) offers a more convenient possibility. It is inserted in the holes (2-21/7) and is secured with the screw (2-21/10) . To do this, use the included ball head screw driver (2-21/12). The included plastic rings (2-21/1) for increasing the knob diameter (2-21/4) for convenient operation at the site are particularly advantageous when sampling large numbers of specimen.

NOTE For a maximum possible scan range with a 24 x 48 format, mount the specimen as shown in Figure 2-21/2!

(2) 45° latch

- The 45° latch is activated by turning the screw (2-21/6) on the vernier scale of the stage (2-21/5) to the right and it is release in the opposite direction (approx. 1/4 turn).

- The latch simultaneously serves to fix the stage in any chosen position.

IMPORTANT When undoing the latch, make sure that this is done out of a latched position as otherwise angular discrepancies will arise when resetting the latch.

(3) Replacing the stage and adjusting stage height

The stage is replaced, e.g. by the universal rotary stage UD 124, as follows:

- Undo the hexagon screw (2-22/4) on the right of the stage until the stage (2-22/1) can be detached from the dovetail guide (2-22/2) (lower the stage slightly to do this).
  The stage is fitted in the reverse order.

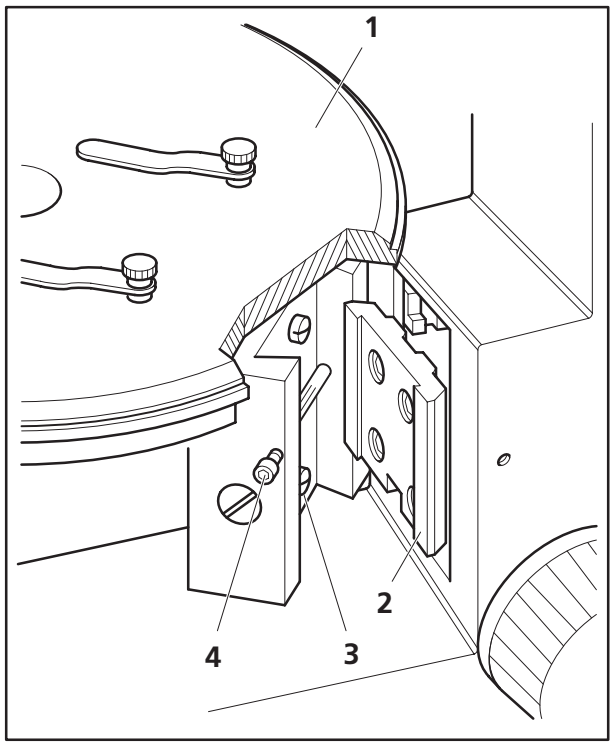


Figure 2-22 Working on the stage

NOTE

- With specimens up to a maximum of 20 mm high, **push** the stage **up** to the bottom stop (2-22/3) and secure it.
- Use the top stop (2-22/5) (to lower the stage) for higher specimens or stage set-ups such as heating chambers (stage set-ups or specimens up to a maximum of 29 mm).

2.7.2 Binocular tubes

(1) Inserting the depolariser (for equipment 0.1 only)

A depolariser is absolutely necessary for analyses of dichroitic or pleochroitic materials (see application in Section 3.1.2 (1)). The binocular tubes Pol of the equipment 0.2 to 0.5 have depolarisers integrated in the tube.

A depolariser (accessory 453675) is offered for equipment 0.1.

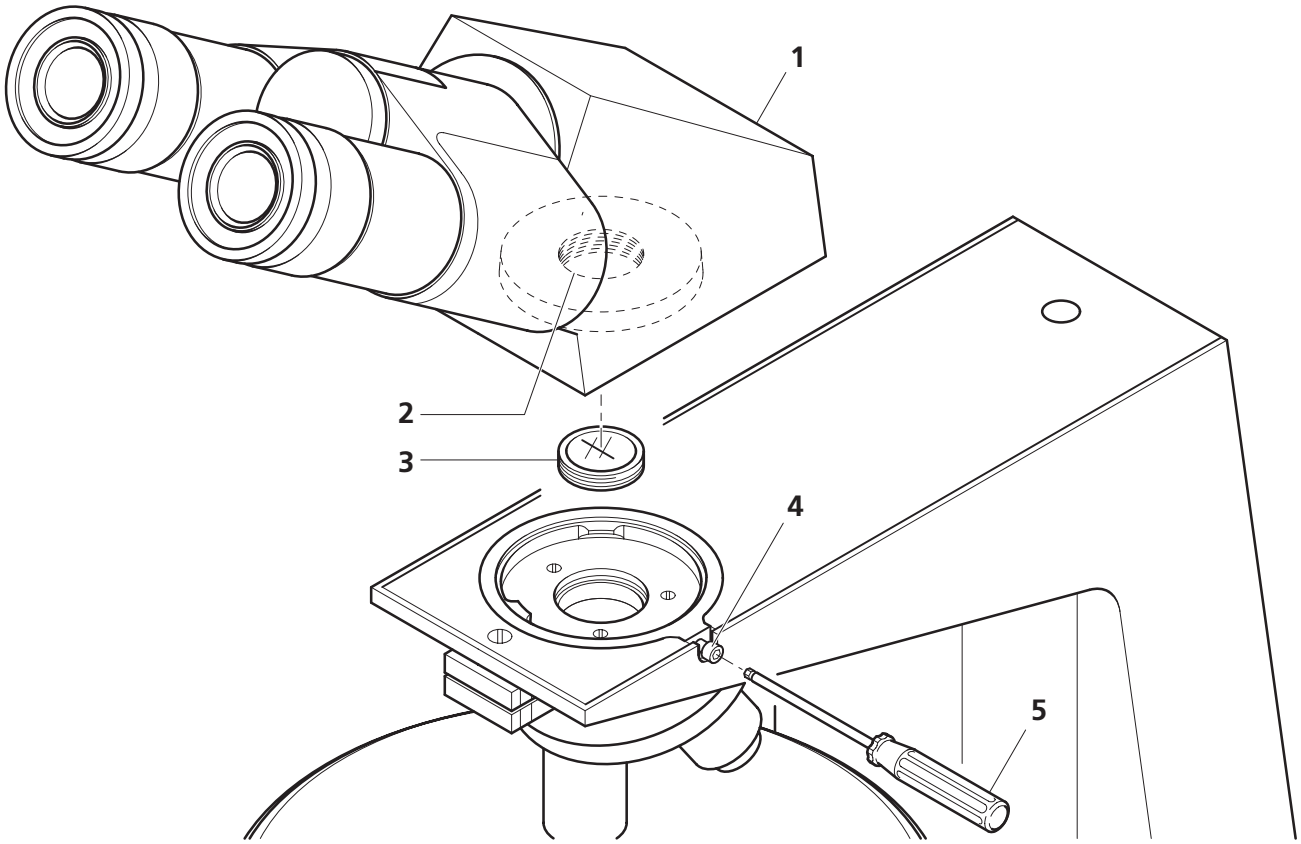


Figure 2-23 Inserting the depolariser

Assembly

- Using the ball head screw driver (2-23/5),, undo the tube from the stand (screw 2-23/4) and turn it round.
- Screw the depolariser (2-23/3) into the opening of the dovetail (2-23/2).

IMPORTANT The numbering on the holder part **must be** upside down!

- Fit the tube back onto the stand, align it and tighten the screw (2-23/4).

(2) Replacing tubes Pol

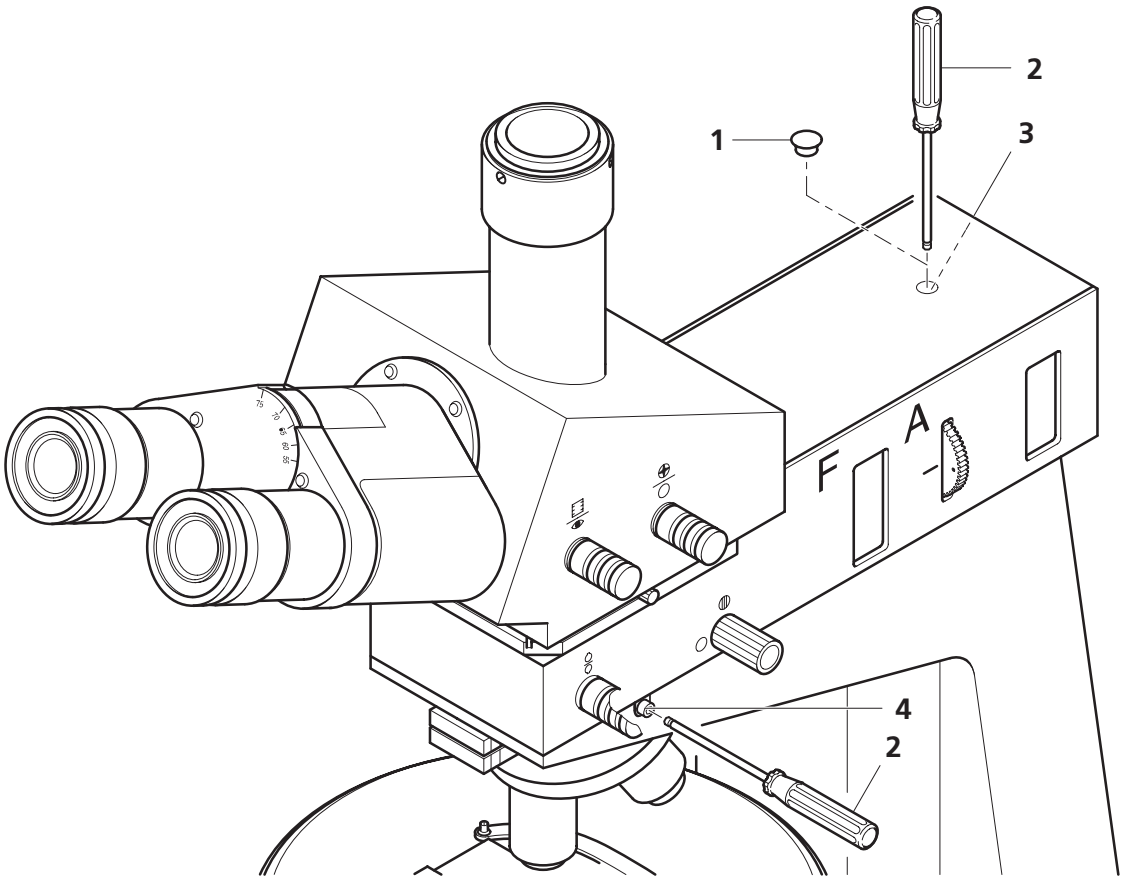


Figure 2-24 Replacing tubes

Except for the tube belonging to equipment 0.1 (see 2-23/1), the tubes Pol are secured on the stand by means of **two** screws.

- To replace tubes, first remove the cover cap (2-24/1). Undo the screw below it (2-24/3) with the ball head screw driver (2-24/2).
- Then unscrew the retaining screw (2-24/4) until the tube can be detached.
- Carry out assembly in the reverse order and, in doing so, pay attention to ensuring that the support screw (2-24/3) is only slightly tightened. Retighten the retaining screw (2-24/4) vigorously and only then retighten the screw (2-24/3).

(3) Replacing the reflected light lamp (for equipment 0.3 and 0.5 only)

Proceed as follows when using other reflecting lighting:

- Dismantle the lamp HAL 6 V 25 W (447206) in the reverse order to the assembly description in Section 2.1 (4).
- It is **imperative** to observe the single operating instructions listed below with regard to operation, installation and replacement of the halogen lamp HAL 100 W, a mercury short arc lamp HBO 50 or the Xenon short arc lamp XBO 75:

  G 42-216/I e microscope lamp HAL
  G 42-160/I e microscope lamp with HBO 50
  G 42-165/e microscope lamp with HBO 100 or XBO 75

NOTE In the reflected light tube, the Axiolab Pol microscope has a **permanently** installed screen and so the lamp must be adjusted with the lamp **detached**.

- Install the lamp or light source and connect it to the external power supply unit as described in the above-mentioned instructions.
- At a distance of approx. 1 m, project the helix or the image of the light source onto a wall surface. To improve imaging, use a hole diaphragm that you have produced yourself (hole diameter approx. 1 cm) and hold in front of the lamp's light outlet opening.

IMPORTANT **Paper or cardboard etc. poses a risk of fire!**
Therefore, **never** leave such aids on the lamp for a prolonged period of time and unsupervised!

Never view directly into these high-power lamps!

The other regulations for your safety, as detailed in the instruction manuals, **must be observed strictly**!

- Adjust the lamp helix or light source image as described in the above-mentioned instructions.
- Fit the lamp on the stand as described in Section 2.1 (4). In doing so, orient the lamp housing perpendicular to the stand so that the lamp mount points downwards (no orientation point available).

NOTE When using these lamps, the uniformity of illumination for the lens 2.5x/0.075 can be improved by slightly readjusting on the focusing screw (symbol with the **horizontal** double arrow). Check this with a homogeneously reflecting object (mirror), while observing the illumination and the edge of the field.

2.7.3 Replacing condensers

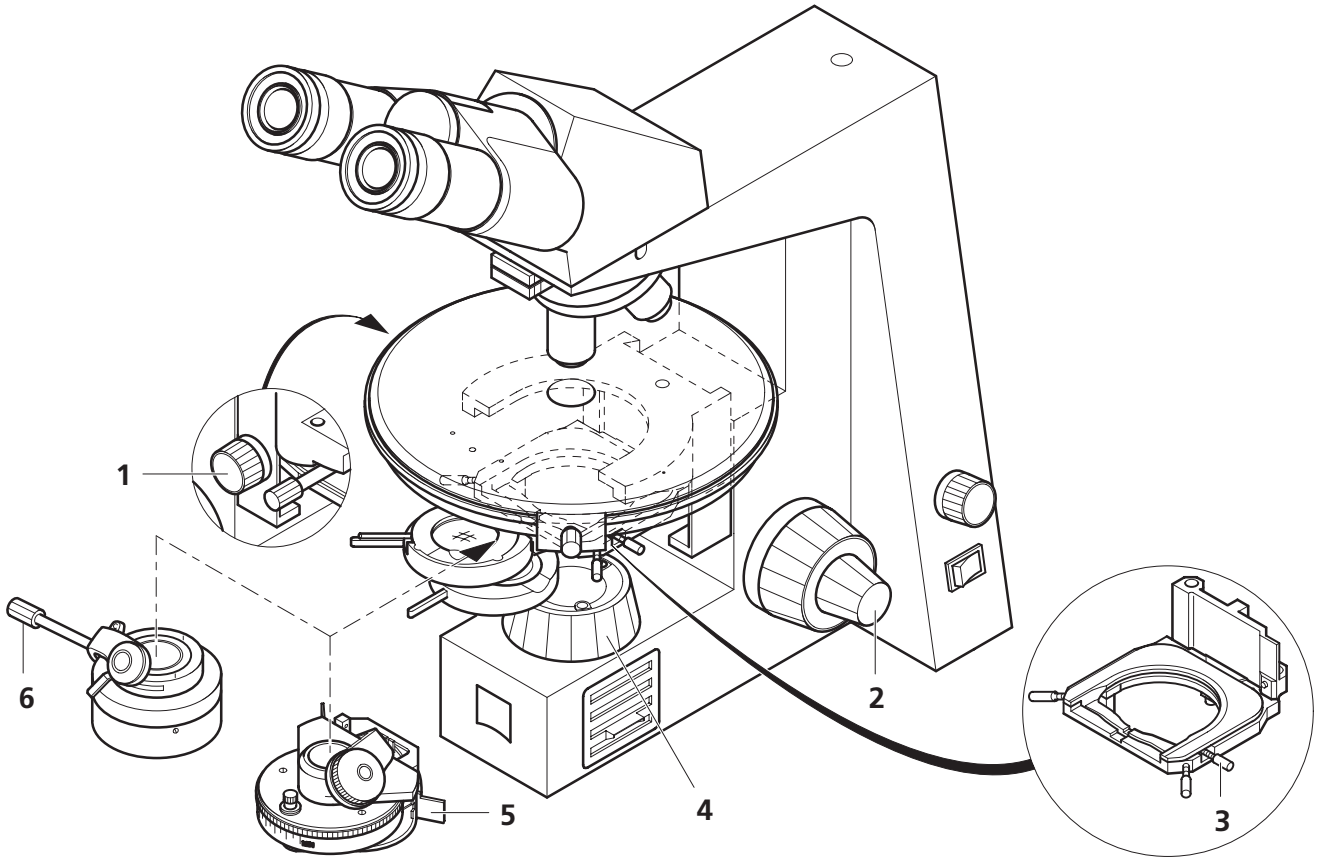


Figure 2-25 Replacing the condenser

- Raise the rotary stage Pol to the stop by means of the coarse drive (2-25/2).
- Lower the condenser carrier by means of the condenser drive (2-25/1) and undo the clamping screw (2-25/3).

IMPORTANT When using the overview unit (445313) or the circular polariser (453623), make sure that the rotary bearings of these units do not press on the luminous field diaphragm (2-25/4).

- Pull the condenser towards you out of the guide fork; if necessary, tilt down the front optics (shift lever (2-25/5 or 6)).
- Insert the other condenser in the reverse order.

2.7.4 Fitting and replacing the polariser

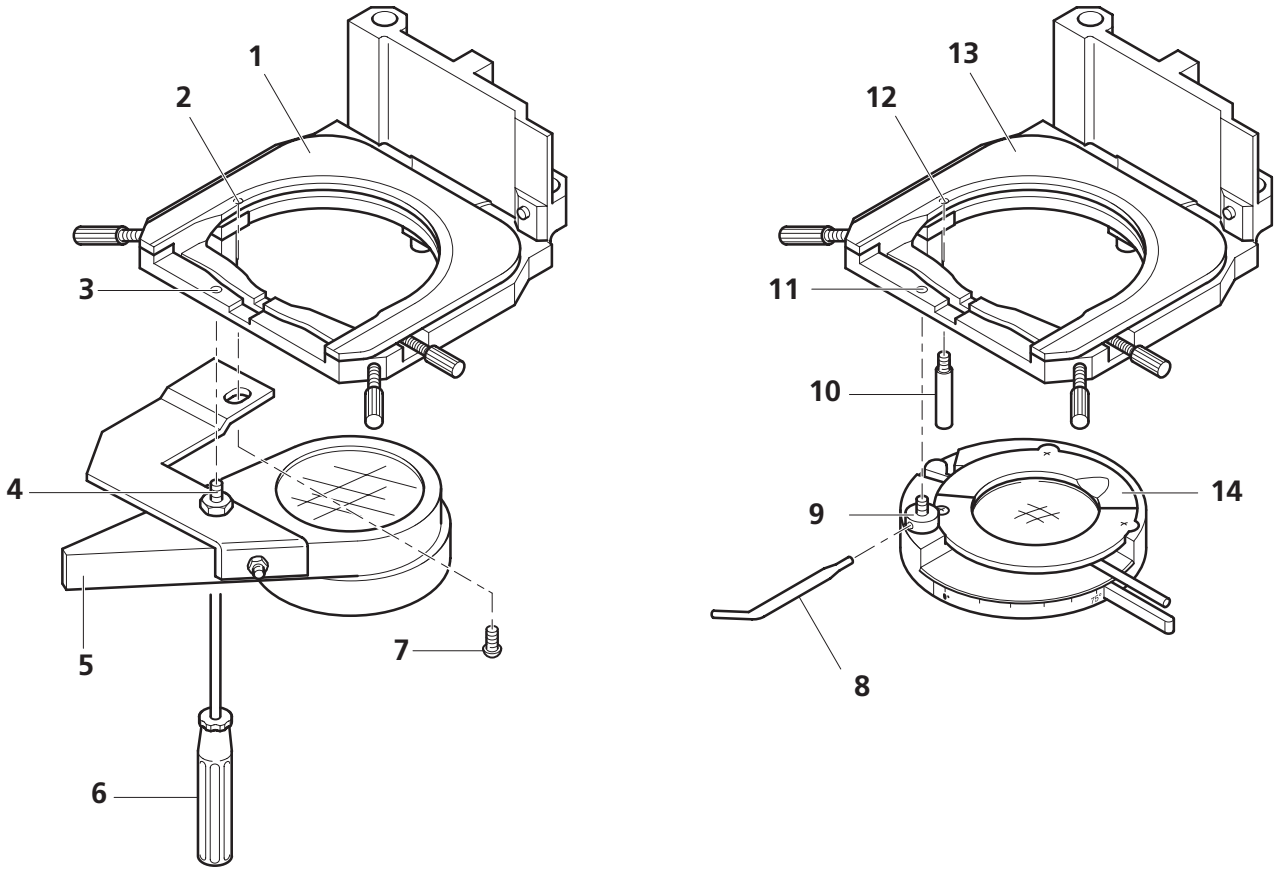


Figure 2-26 Polariser assembly

- The swivelling polariser (2-26/5) is secured at two screw-on points (2-26/2 and 3) under the condenser carrier (2-26/1).

- For installation or removal, use the ball head screwdriver (2-26/6) and a normal screwdriver. **For installation**, first secure the screw (2-26/4) at the screw-in point (2-26/3) and then the screw (2-26/7) at the screw-in point (2-26/2).

- First secure the polariser D, rotary (453620) (2-26/14) at the screw-in point (2-26/11) using the key (2-26/8) and then secure the latching rod (2-26/10) at the screw-in point (2-26/12).

- Carry out disassembly in the reverse order.

NOTE The polarisers have been optimally aligned at the works. In certain circumstances, slight readjustment analogous to Section 2.7.6 may be necessary during the course of replacement.

2.7.5 Assembling and using the overview unit, swivelling for lens 1.25x (accessory 445313 - for equipment 0.4 and 0.5)

For overview observation in a specimen field Ø = 16 mm (when using the Plan-Neofluar 1.25x/0.04 ∞ lens / accessory 440300) in transmitted light bright field or polarisation mode, the above-mentioned overview unit is needed to illuminate the field.

- To facilitate assembly, detach the rotary stage from the stand as described in Section 2.7.1 (3).
- Using a screwdriver, first unscrew the fillister head screw (2-27/2) on the underside of the polariser D, rotating (2-27/1).
- Screw the analogous bearing screw of the large field lens (2-27/4) into the now exposed threaded hole in the rotary bearing of the polariser (use key (2-27/5) to do this).

NOTE Re-insert the spring washer (2-27/3) on assembly.

- Screw on the extended latching rod (2-27/6) analogously to the polariser D, rotating (Section 2.7.4) after removing the latching rod (2-27/7).
- Insert the condenser as described in Section 2.7.3 and raise it by means of the condenser drive (2-25/1).

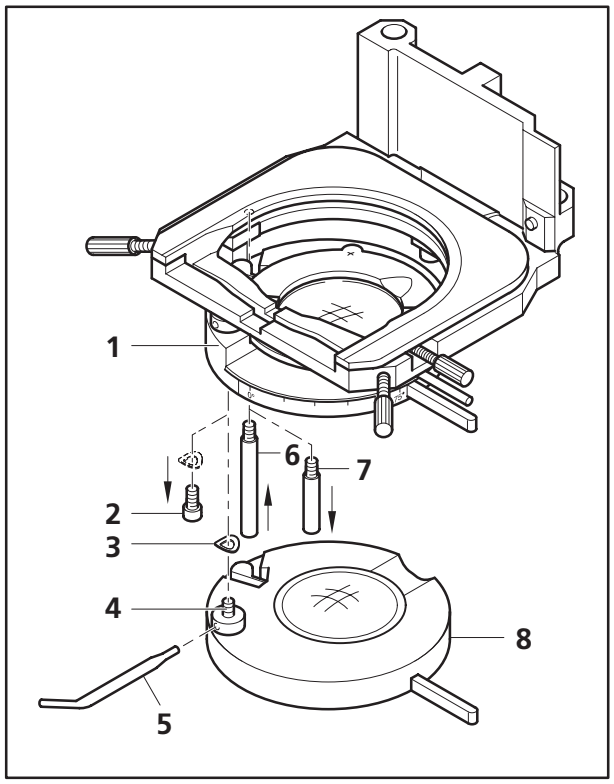


Figure 2-27 Using the overview unit

- Position the rotary stage on the stand as described in Section 2.7.1 (3) and slide it up until the bottom stop (2-19/3) takes effect, and secure it here.

IMPORTANT When a polariser and overview lens are combined, the stage lowering range is limited to 12 mm!
In doing so, use must not be made of higher specimens, particularly when carrying out reflected light analyses (equipment 0.5)!

- After adjusting the KÖHLER lighting as described in Section 2.6.1 (3), tilt away the front optics of the condenser with the shift lever (2-25/5) and swivel in the overview lens up to the latching position.

NOTE In order to use the overview unit, the aperture diaphragm (2-12/5) (see condenser adjustment) must be opened fully! The illustrated luminous field diaphragm is opened up to the edge of the field of vision by means of the setting ring (2-12/4).

2.7.6 Assembling the circular polariser D (accessory 453623)

- After removing the polariser and, if necessary, the latching rod (see Section 2.7.4), the circular polariser D and the extended latching rod can be fitted analogously to the polariser D, rotating.
- Prepare the microscope as described in Sections 2.6.1, 2.6.2 (1) and (2).

NOTE **Do not use** a specimen for the further adjustment steps!

- Swivel in the polariser (2-28/3) – bottom flap – up to the latching point and observe extension (dimming of the field of vision without a specimen) at the full light output.
  If this is not optimum, use a small screwdriver to correct the position of the polariser's oscillation direction by turning slightly and sensitively on the holder – use the adjustment slots (2-28/4) – until maximum extension has been achieved.

- After removing the dust protection slide, slide the affiliated compensator slide λ/4 (2-28/5) into the compensator slot and swivel in the λ/4 plate (2-28/2) – top flap – on the circular polariser D.

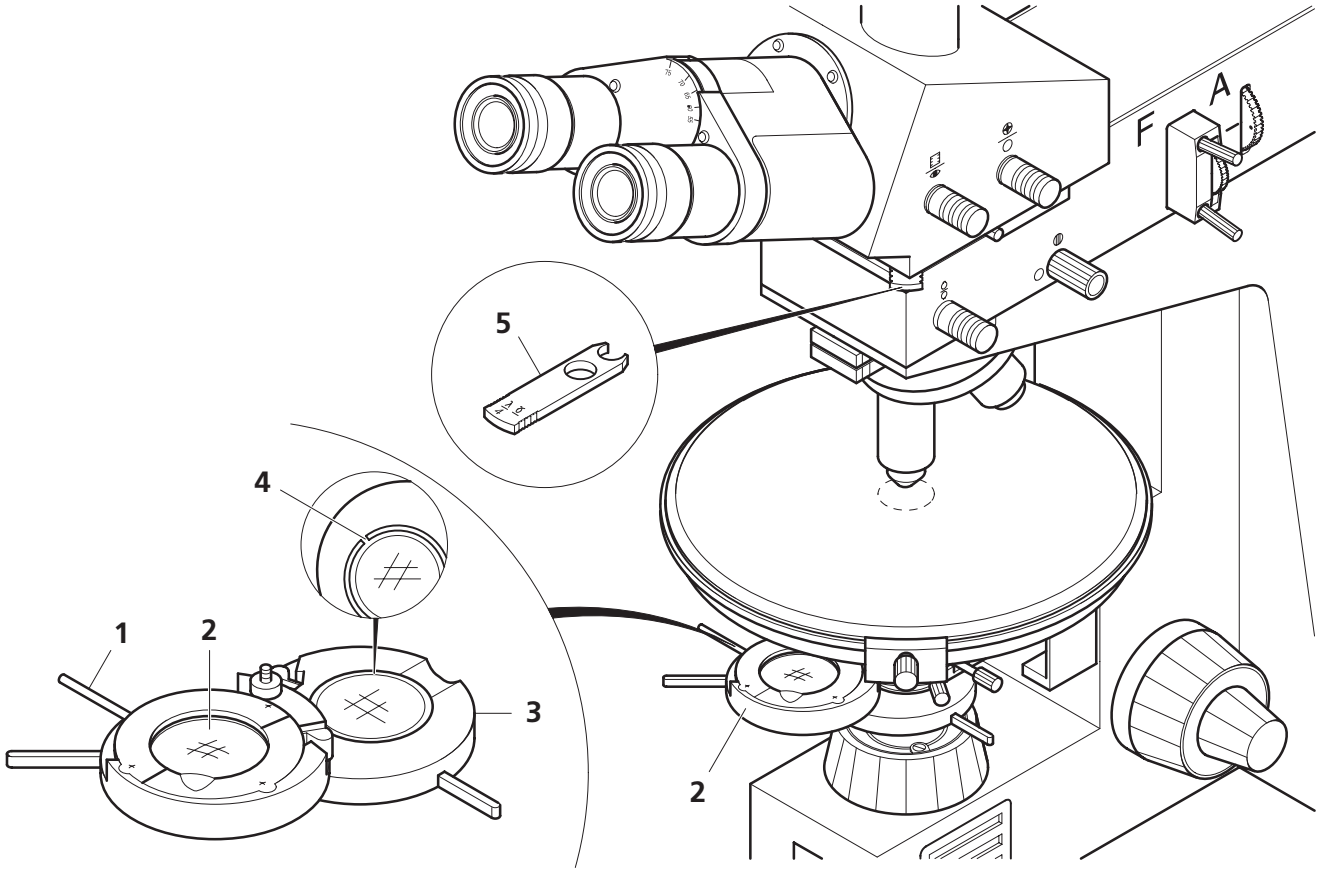


Figure 2-28 Circular polarisation unit

- On the control for the rotary bearing (2-28/1), turn the plate until maximum extinction (dark grey field of vision) is achieved (the lever points 45° to the right).

- An (anisotropic) specimen should not be observed until the above-mentioned adjustments have been made.

Specimens appear constant and, independently of rotation of the stage, in their interference colour, which depends on the material, the thickness of the specimen and its orientation.

NOTE For an image rich in contrast, when using higher lens magnification factors (as from approx. 20x) reduce the illumination aperture to a value between 0.15 – 0.20, i.e. close the aperture diaphragm accordingly.

2.7.7 Assembly and use of a phase contrast unit (accessory 445303 or 445366)

Phase contrast is used to contrast undyed specimens (phase specimens), to depict refractive index differences, e.g. as the result of growth homogeneities or to determine the refractive index more precisely in accordance with the embedding method using immersion fluids of differing refraction (see Section 3.1.2 (2)).

This method requires the following additions:

- For equipment 0.1 to 0.3:
  ABBE condenser 0.9/1.25 with 5-fold turret disk (accessory 445303)
  for bright field,
  for phase contrast, the ring diaphragms Ph1, Ph2, Ph3 or
  dark field (0.65/0.9) – for the CP-Achromat 40x/0.65 –

- For equipment 0.4 and 0.5:
  for the achr. apl. system condenser 0.24 Pol (445325) with front optics 0.9 Pol (445331)
  the turret disk H D Ph (accessory 445366)
  for bright field,
  for phase contrast, the ring diaphragms Ph1, Ph2, Ph3 (accessory 445369 - 71)
  if applicable, dark field

To do this, use lenses with the additional designation "Ph1, Ph2 or Ph3" (see Section 1.4 (2); accessories 8 ff.).

- The ABBE condenser 0.9/1.25 with turret disk (Figure 2-30) is fitted on the unit as described in Section 2.7.3.

- After undoing the screw (2-29/1) with the ball head screwdriver (2-29/4), take out the bright field insert (2-29/2) and replace it by the turret disk (2-29/5).

- On both condensers, turn the turret disk to the position HF or H by way of the read-off index (2-29/8).

- The basic settings for transmitted light/bright field detailed in Section 2.6.1 are the prerequisite for the following adjustment.

- First of all sharply focus the specimen in the bright field and open the luminous field diaphragm (2-25/4) up to the edge of the field. For low-contrast specimens, it helps to close the aperture diaphragm (move the slide (2-30/1) or the knurled ring (2-29/7) in the direction of 0.2 or 0.3 on the aperture scale).

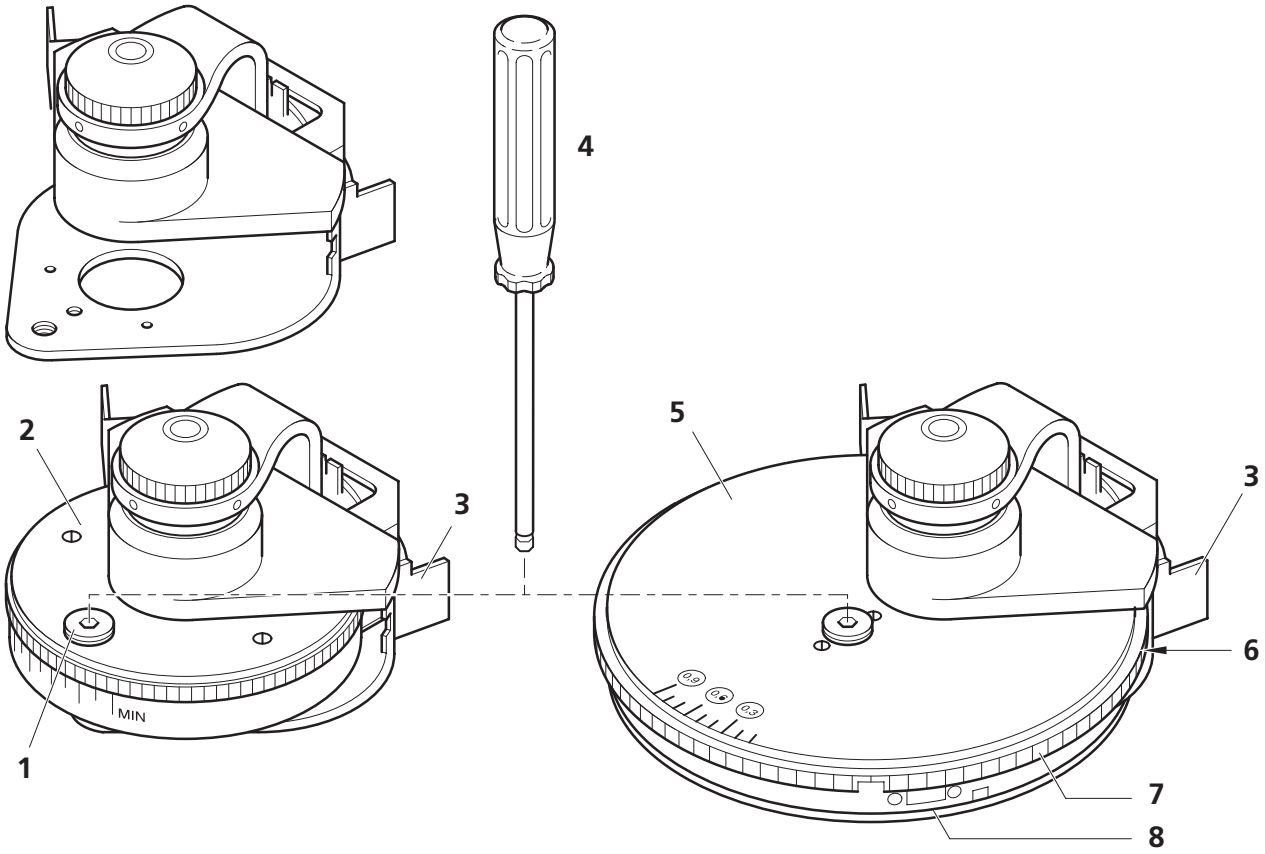


Figure 2-29 Phase contrast unit for equipment 0.4 and 0.5

- Swivel in the lens 10x Ph1, if available, **and** allow the affiliated ring diaphragm Ph1 to engage on the turret disk.

- Complete phase contrast is achieved only if the dark phase ring in the lens and the "bright" ring diaphragm are precisely flush (Figure 2-31).

- The ring diaphragms in the ABBE condenser are centred by means of the centring screws (2-30/2). To fix this setting, tighten the screw (2-30/3).

NOTE In the case of the system condenser, there are centring screws behind two openings (when the front optical system is swivelled in, before the right-hand (2-29/6) or behind the left-hand swivel lever).
Use two keys (1-3/14) for centring.

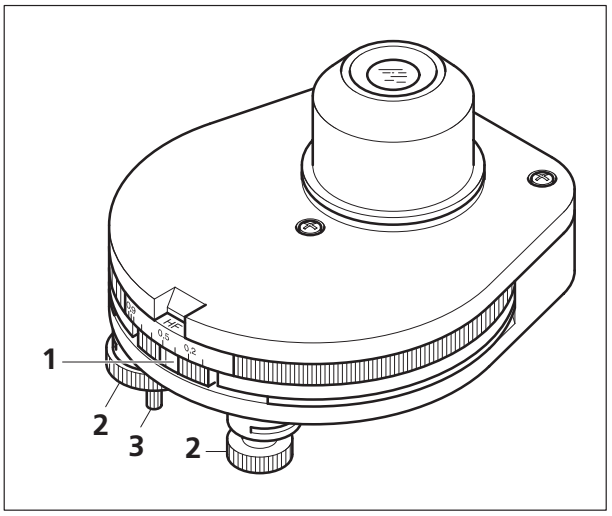


Figure 2-30 ABBE condenser 0.9/1.25

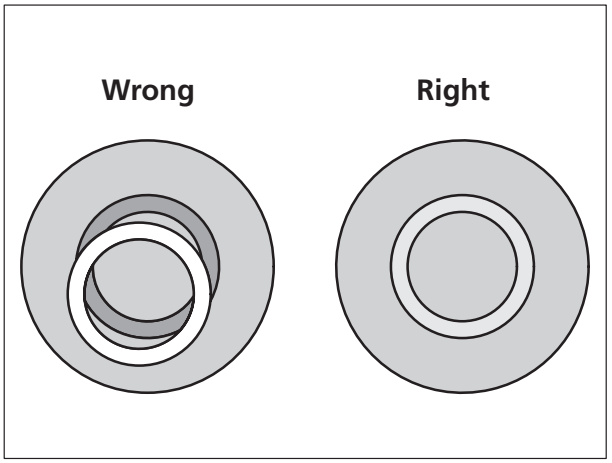


Figure 2-31 Centring the ring diaphragms

- Check the centring of both rings with the BERTRAND lens activated (2-17/1) (equipment 0.2 - 0.5 – see Section 2.6.2 (4)); for equipment 0.1, with the eyepiece pulled out, at the base of the eyepiece connection or, better, inserted through an auxiliary microscope (accessory 444830) in an eyepiece connection and focused on the ring diaphragm plane.

- Adjust the brightness of the lamp according to the specimen.

IMPORTANT More than bright field, phase contrast requires particularly clean glass/air interfaces on the specimen and the optical system (avoid fingerprints).

2.8 Microphotography / video microscopy / photometry (equipment 0.4 and 0.5 only)

With the aid of the push rod (2-10/4) on the binocular photo tube, the Axiolab Pol microscope can be switched over from visual observation to microphotography/video microscopy(" " symbol). As this involves 100 % switchover on the photo tube Pol, visual viewing while taking photographs/ video shots is not possible.

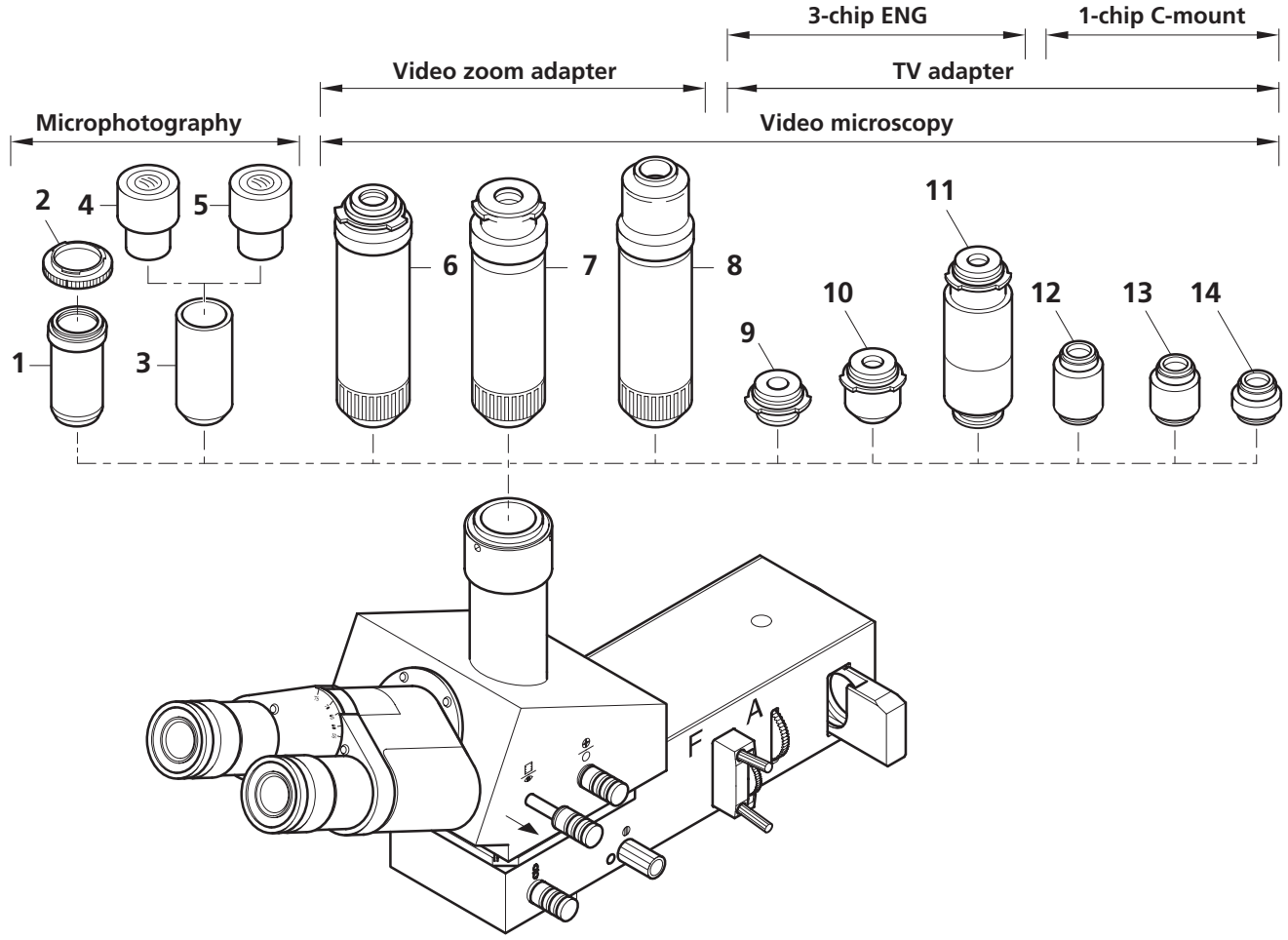


Figure 2-32 Connectors for microphotography and video microscopy

1	Connector for single lens reflex camera 2.5x for T2	456005
2	T2 adapter (example; obtainable for all conventional camera systems)	–
3	Microscope camera connector, d = 30 mm	456006
4	Projection lens P 2.5x for MC 80 (miniature format 25x36 mm)	456021
5	Projection lens P 10x for MC 80 (large format 4x5")	456023
6	Video zoom adapter 0.4x - 2x 2/3" ENG	456121
7	Video zoom adapter 0.4x - 2x 1/2" ENG	456122
8	Video zoom adapter 0.4x - 2x C-mount	456123
9	TV adapter 60 ENG 2/3" 1.0x	456115
10	TV adapter 60 ENG 2/3" 0.8x	456117
11	TV adapter 60 ENG 1/2" 0.63x	456118
12	TV adapter 60 C 2/3" 1.0x	456105
13	TV adapter 60 C 2/3" 0.63x	456107
14	TV adapter 60 C 1/2" 0.5x	456106

2.8.1 Microphotography

In relation to microphotographic units, attention must be paid to the individual operating instructions listed below in addition to the information given in this manual:

G 42-406/II 35 mm SLR cameras for microscopes and stereomicroscopes
G 42-407/I Microscope camera MC 80
G 42-401/II Microscope camera MC 100 Spot
G 42-402 Data back panel for MC 35 Mot

(1) Miniature photography with single lens reflex camera (e.g. CONTAX 167 MT)

- Screw the T2 adapter (2-33/3) matching the camera system used onto the connector 2.5x for T2 (2-33/4).
- Fit the camera (2-33/2), if necessary attaching the release (2-33/1).
- Remove the dust protection cap (2-33/7) from the photo tube (2-33/5) and insert the pre-assembled unit A in the photo tube.
- Align the unit in the required position and secure it with the three hexagon screws (2-33/6).

NOTE If it is not intended to focus via the camera's viewfinder, a format reticule plate must be screwed into the eyepieces. See Section 2.4 (2).

The manufacturer's document G 42-406/II "35 mm SLR cameras for microscopes and stereomicroscopes" contains detailed information of the SLR cameras.
The camera manufacturer's notes must also be observed.

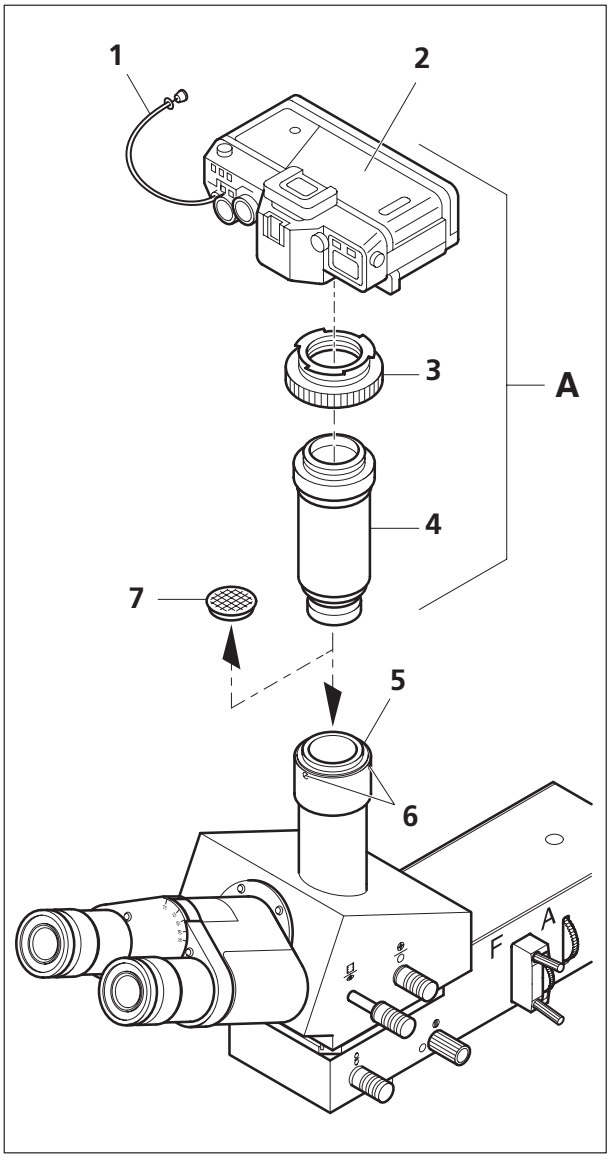


Figure 2-33 Attaching a single lens reflex camera

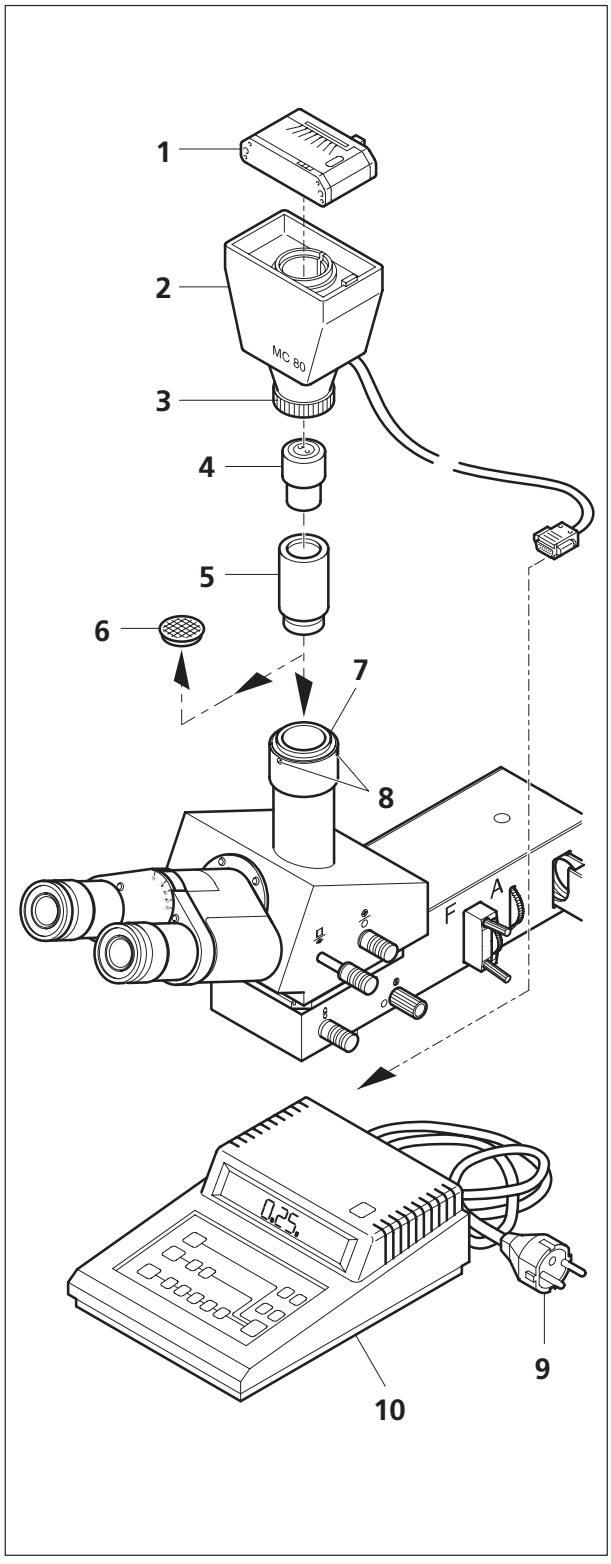


Figure 2-34 Connecting the microscope camera MC 80

(2) Miniature photography with the microscope camera MC 80

- Detach the dust protection cap (2-34/6) and insert the microscope MC 80 connector (2-34/5) in the photo tube (2-34/7) and secure it with the three hexagon screws (2-34/8).
- Insert the projection lens P 2.5x (2-34/4).
- Fit the base (2-34/2) until it bottoms and fix it with the knurled ring (2-34/3).
- Insert film.
- Insert the film cartridge (2-34/1) (the EJECT knob springs out). To remove it, press the EJECT knob.
- Connect the connecting cable of the base (2-34/2) to the exposure control (2-34/10).

IMPORTANT The voltage of the exposure unit must correspond to the mains voltage.

- Plug in the mains plug (2-34/9).

The manufacturer's document G 42-407/I "Microscope camera MC 80" contains detailed information on the microscope camera MC 80.

(3) Miniature photography with the microscope camera MC 100 (integral and spot exposure metering)

- Detach the dust protection cap (2-35/6) and insert the microscope camera connector (2-35/5) in the photo tube (2-35/7) and secure it with the three hexagon screws (2-35/8).
- Insert the photo eyepiece S-Pl 10x / 20 (2-35/4).
- Fit the base (2-35/2) until it bottoms and fix it with the knurled ring (2-35/3).
- Insert film.
- Insert the film cartridge (2-35/1) (the EJECT knob springs out). To remove the cartridge, press the EJECT knob.
- Connect the connecting cable of the base (2-35/2) on the exposure control MC 100 (2-35/10).

IMPORTANT The voltage of the exposure unit must correspond to the mains voltage.

- Insert the mains plug (2-35/9).

Proceed as follows to arrive at the correct exposure metering results in the polarisation mode:

Move the microscope camera to the operating position. Read off the exposure time, e.g. 1.00 s.

Undo the hexagon screw for camera orientation and turn the camera by approx. 90°. Read off the exposure time, e.g. 0.32 s. This exposure time corresponds to the required value.

Turn the microscope back to the operating position and fix it in this position. Set the required value by means of exposure control. This correction value is valid for all lens magnification factors, provided the analyser is in the beam path.

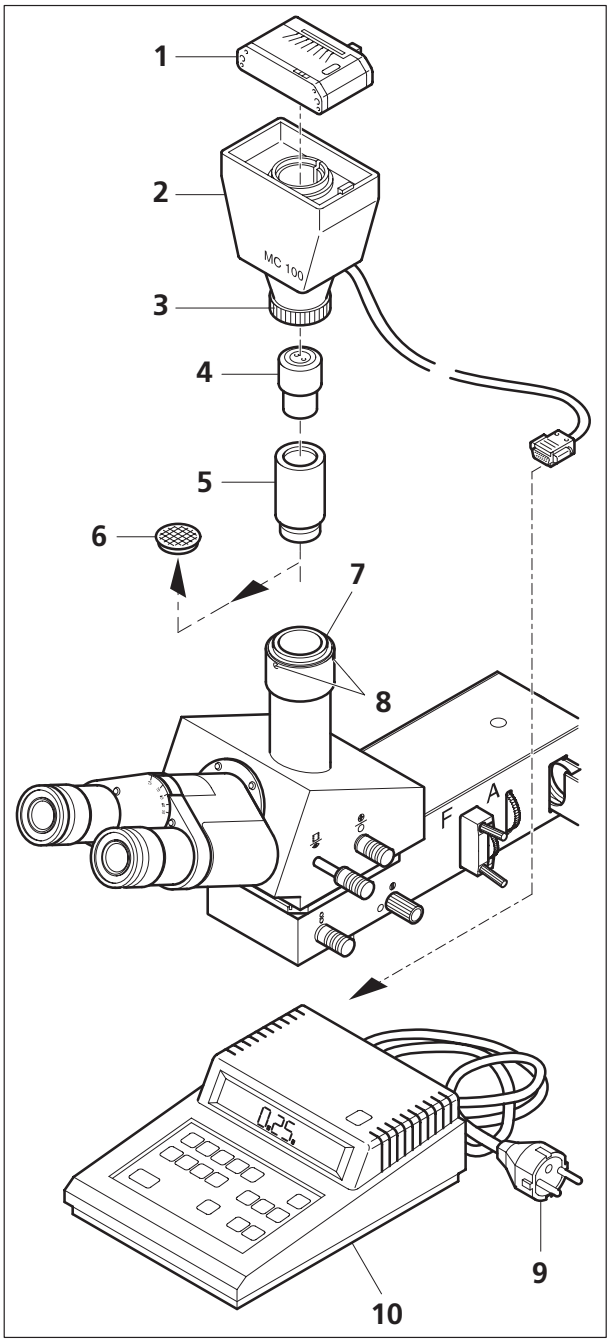


Figure 2-35 Connecting the microscope camera MC 100

Use of a depolariser in the photo output (please enquire about adaptation possibilities) offers a further solution without exposure time correction.

The manufacturer's document G 42-401/II "Microscope camera MC 100 Spot" contains detailed information on the microscope camera MC 100.

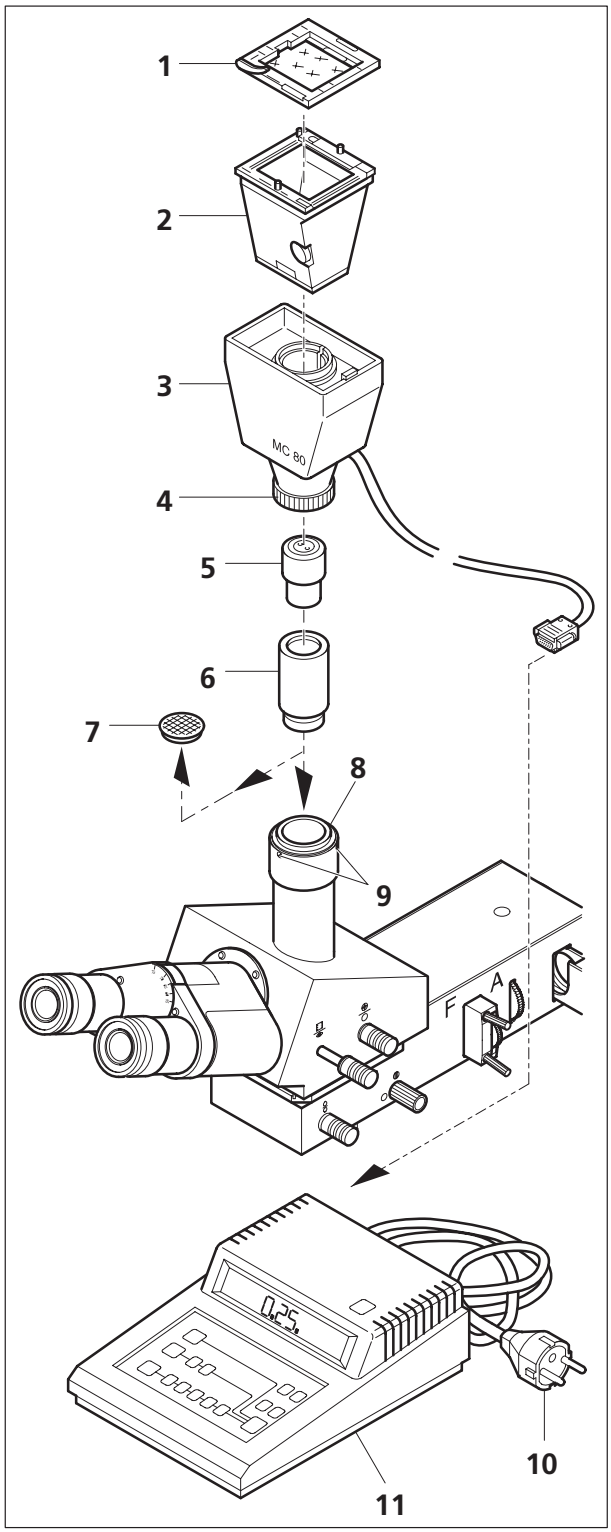


Figure 2-36 Connecting the microscope camera MC 80 for large format 4x5”

(4) Large-format photography with the microscope camera MC 80

- Insert the connector of the microscope camera MC 80 (2-36/6) in the photo tube (2-36/8) and secure it with the three hexagon screws (2-36/9).
- Insert the projection lens P 10x (2-36/5).
- Fit the base (2-36/3) until it bottoms and fix it with the knurled ring (2-36/4).
- Insert the large-format attachment 4x5” (2-36/2) with the large-format screen and the cartridge mount (2-36/1).
- Connect the connecting cable of the base (2-36/3) on the exposure control (2-36/11).

IMPORTANT The voltage of the exposure control must correspond to the mains voltage.

- Insert film.
- Plug in the mains plug (2-36/10).

The manufacturer’s document G 42-407/I ”Microscope camera MC 80” contains detailed information on the microscope camera MC 80.

2.8.2 Video microscopy (equipment 0.4 and 0.5 only)

On the Axiolab Pol microscopes, video microscopy is possible via the photo tube using **TV adapters** and **video zoom adapters**. The video zoom adapters with continuously variable factors within the range from 0.4x - 2.0x permit reproduction of standard enlargements on video prints.

Section 2.8 contains an overview of the adapters on offer.

In the low-factor range, the video image is truncated in a circular fashion when using video cameras with a 2/3" and 1" chip on the video zoom adapters.

Video zoom adapter	Large camera chip	Truncation for factor
2/3"-ENG	2/3" (∅ 11 mm)	< 0.5 x
C-mount	2/3" (∅ 11 mm)	
	1" (∅ 16 mm)	< 0.7 x

- Detach the dust protection cover (2-37/4) from the photo tube (2-37/6).
- A diaphragm for 2/3" chip video cameras is inserted in the threaded connector of the video zoom adapter with C-mount. When connecting video cameras with chip sizes of 1/3", 1/2" or 1", the inserted 2/3" diaphragm must be replaced by a diaphragm corresponding to the chip size and marked accordingly.
- Screw in the TV adapter/video zoom adapter with C-mount in the video camera (2-37/1). Insert and clamp the TV adapter (2-37/3) / video zoom adapter (2-37/2) in the 2/3" or 1/2" ENG bayonet of the video camera.
- Insert the pre-assembled unit (video camera with TV adapter / video zoom adapter) in the photo tube, align it (on the video zoom adapter, the index line – see arrow – should point towards the viewer) and clamp it with the three hexagon screws (2-37/5).

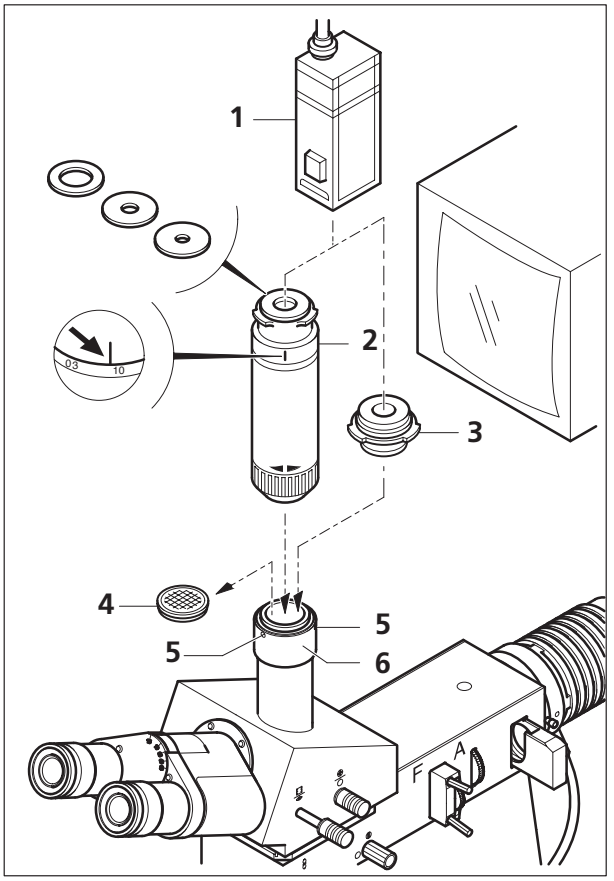


Figure 2-37 Connecting the video camera

2.8.3 Photometry (equipment 0.4 and 0.5 only)

Refer to the instructions B 40-030 for a description of the microscope photometer and how to use it.

Photometry with the attachment photometer MPM 100 (accessory 457325) is possible on Axiolab Pol equipment with a photo tube and via the photo/TV connector. The push rod (2-38/5) (symbol " ")serves to switch over to the photo output.

This is a 100 % changeover, i.e. simultaneous visual observation is not possible while determining photometric data.

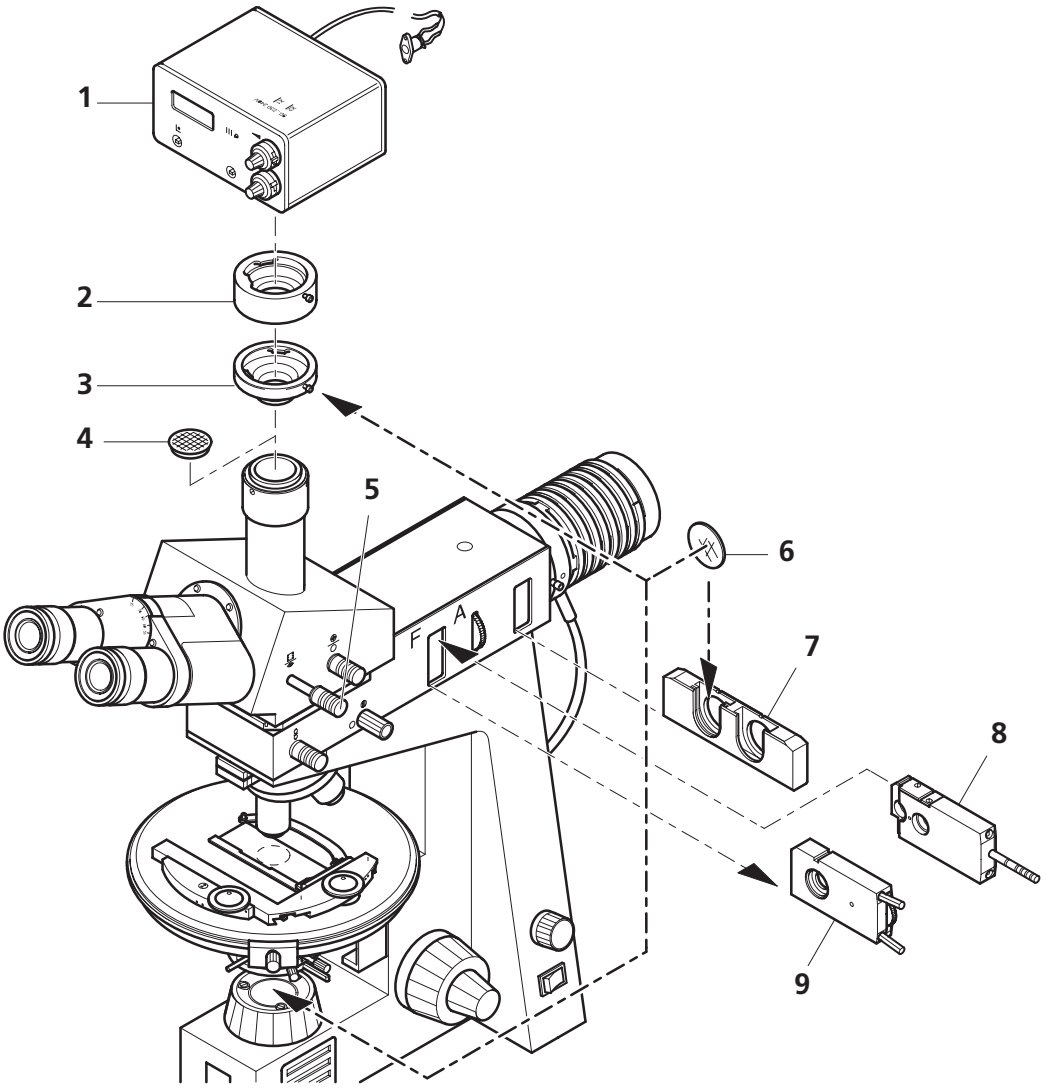


Figure 2-38 Connecting the MPM 100

- Remove the dust protection cap (2-38/4) and, instead, connect the connector 44-20 (2-38/3) of the MPM to the photo output.

- Insert the attachment piece 60-44 (2-38/2) (accessory 456140) in the connector 44-20.

- By means of the clamping screw, secure the attachment photometer (2-38/1) on the attachment piece 60-44, using the ball head screwdriver to do this.

- For transmitted light analyses in the visible spectral range, the reflection thermal protection filter d = 2 x 32 (2-38/6) (accessory 467832) is needed and must be placed on the microscope's light outlet opening.

- For reflected light analyses, use the reflection thermal protection filter that is permanently installed in the reflected light beam path. To support it, the filter (467832) can be additionally placed in the filter slide (2-38/7).

- For reflected and transmitted light analyses, the best place for this filter is in the connector 44-20 (2-38/3) itself (to do this, pull the snap ring out of the connector, insert the filter up to the collar and secure it again by means of the snap ring).

- The eyepiece Pol with integrated reticule must be replaced by the eyepiece E-Pl 10x/20 P spec. foc. with integrated eyepiece circle plate (accessory 444092-9901) (refer to the operating instructions of the MPM 100, B 40-030).

- The slide A for fixed diaphragms (accessory 457378) (2-38/8) is recommended to reduce extraneous light in reflected light modes. It replaces the luminous field diaphragm slide (2-38/9).

- In order to use the photometer, carry out the basic settings described in Section 2.6 ff. and observe the instructions in the manual of the MPM 100 (B 40-030).

3 Application examples

3.1 Transmitted light applications

3.1.1 Determinations without polarisers (transmitted light bright field)

Generally, the production of a thin grind or a dispersion specimen is a prerequisite for assessment.

Among other things, the following can be assessed on such a prepared specimen:

- The intrinsic colour of the substance containing colour inhomogeneities as the result of trapped deposits and growth irregularities and the presence of striations in the material.
- The transparency of the material which, for example, may be detrimentally influenced by sub-microscopic trapped deposits or extremely fine demixing or conversion processes.
- Divisibility and its characteristic location with regard to crystallographic morphology (see also "Determining extinction inclination", Section 3.1.3 (2)).
- On a dispersed specimen, particularly in the case of isotropic (or cubic) substances, of the relative refraction of the substance in comparison with the embedding material (see also "Determining the refractive index", Section 3.1.2 (2)).
- On a thin grind or a prepared grain compound, the porosity of a material can be assessed and the proportion and amount of cavities can be considered.

To do this, the following prerequisites must be created on the microscope:

- Prepare the microscope as described in Section 2.6.1 (1) to (3).
- Switch off the polarisers (3-1/4) and the analyser. (To do this, pull the push rod (3-1/2) or the analyser slide ((3-1/1) – equipment 0.1 only –).
- If necessary, reduce the illumination aperture on the setting control for the aperture diaphragm (3-1/3) to 2/3 of the lens aperture or more.
- Optimally set up illumination of the object (bright, but without dazzle), using the neutral and grey filter, and a conversion filter for colour assessment (3-1/5).

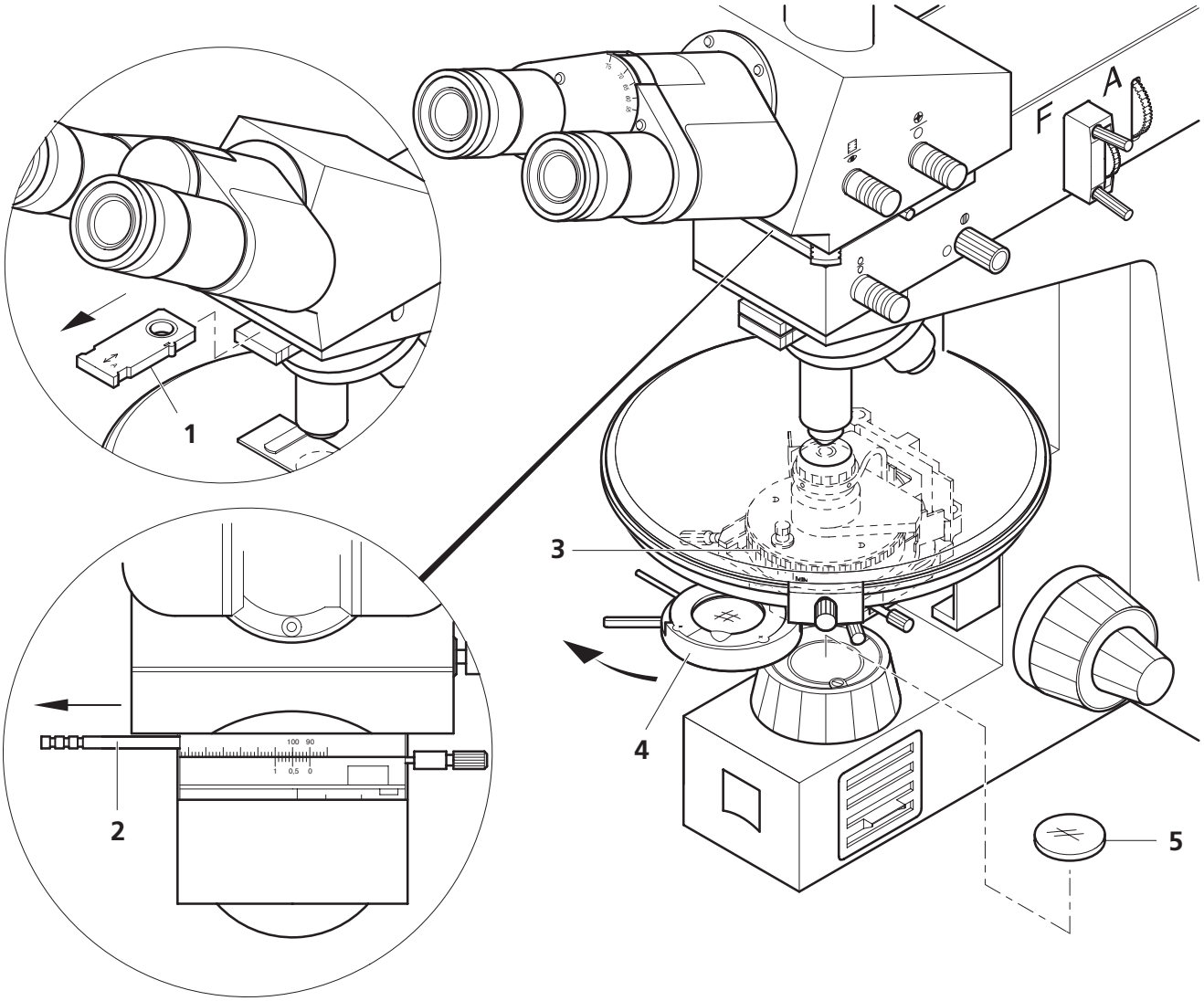


Figure 3-1 Transmitted light bright field determinations

3.1.2 Determinations with a polariser (dichroism)

(1) Assessment of dichroism or pleochroism

When linear polarised light passes an anisotropic object with a slightly absorbing characteristic, a direction dependence of this absorption can frequently be observed. When the rotary stage Pol is rotated, the intensity of absorption or, in certain circumstances also the colour of the specimen as the result of wavelength dependence changes. To assess this characteristic, an extinction position of the specimen must be chosen as the starting position (see also Section 3.1.3 (1)) and, to start off, the basic setting with crossed polars is necessary.

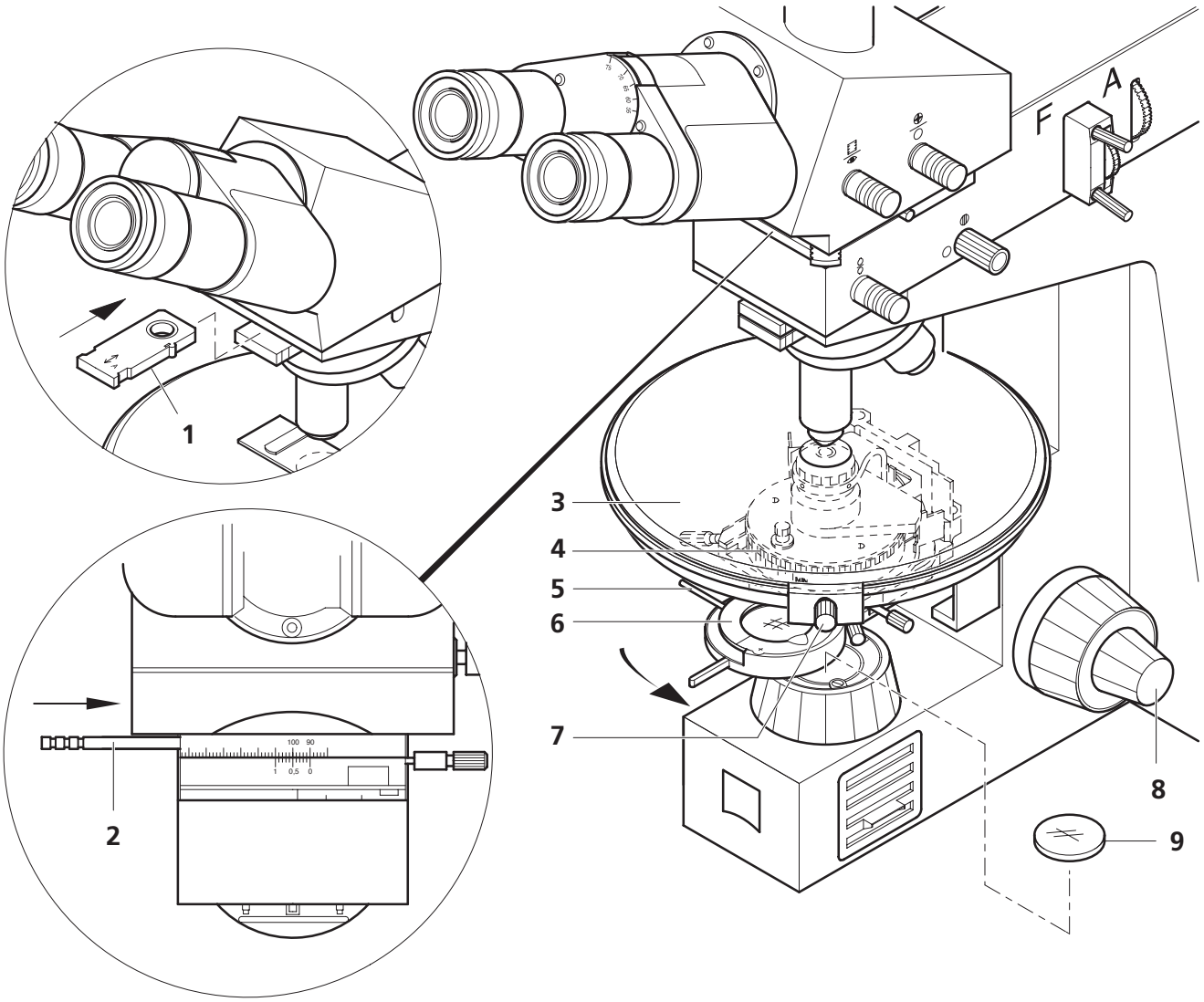


Figure 3-2 Determinations with one polar

- Set up the microscope as described in Section 2.6.1 (1) to (3) and position the analysed specimen in the middle of the field of vision (over the reticule, if available).

- Swivel in the polariser (3-2/6) and push in the analyser push rod (3-2/2) or the analyser slide ((3-2/1) – equipment 0.1 only –) and, if applicable, align the polars as described in Section 2.6.2 (2, 3).

- Restrict the illumination aperture on the setting control for the aperture diaphragm (3-2/4) to 0.2.

- Turn the rotary stage Pol (3-2/3) until the specimen is in the extinction position, i.e. it appears completely dark and set the 45° latch (3-2/7) here by turning to the right.

- Now pull out the analyser push rod (3-2/2) or the analyser slide ((3-2/1) – equipment 0.1 only –) again.

- Optimally set up specimen lighting (bright, but without dazzle); if necessary, use the neutral and grey filter to do this and use a conversion filter (3-2/9) to assess the colours.

- Either turn the specimen over **two** latching positions on the rotary stage or, when using the polariser D, rotating (453620), turn the control (3-2/5) to the 90° latching position, i.e. turn the lever to the right and **assess** the **intensity conditions and colour** on the specimen in both positions.

(2) Determining the refractive index in accordance with the immersion method

The immersion method is suitable for easy determination of a specimen's refractive index. For example, an **isolated** isotropic or anisotropic specimen (grains or fibres etc.) is embedded as a dispersed specimen in liquids of differing, but known, refractive index (if necessary, determine the refractive index of the liquid using a refractometer). The contours of the specimen disappear if the refractive index of both the specimen and the embedding medium agrees; it is then practically no longer visible.

BECKE's line should be used for orientation and for precise determination. It appears as a **bright line of light when defocusing a previously sharply focused specimen with the fine drive** and is caused by diffraction effects at the transition between the specimen and the environment.

The following rule applies:
When the **distance between the specimen and lens is increased** by moving the fine drive (3-2/8), this line of light wanders **into the higher-refracting medium**. When the refractive index is approached, this line becomes increasingly weaker and disappears practically completely when the refractive indexes are equal.

This criteria can be used for estimation (specimen has a higher or lower refraction than the embedding medium) in order to thus determine the direction for further embedding experiments up to refractive index equipments.

In doing so, attention must be paid to the fact that, in the case of an **anisotropic** (double-refracting) specimen, **two different** (relative) refractive indexes characterising the intersecting position exist

in the direction of the beam (see Section 3.1.3 (1)). To determine them individually, illuminate the specimen with **linear polarised** light analogously to Section 3.1.2 (1) and turn the specimen to the extinction position with the polars previously crossed. Switch off the analyser (3-1/2). The determined refractive index now refers to the oscillation direction given by the polariser (and marked with the horizontal part of the eyepiece reticule, if installed).

The refractive index in the second direction is determined, either after turning the specimen by 90° (with the latch set, latch on the rotary stage 2x) or, if available, by turning the control (3-2/6) on the polariser D, rotating (453620) to the 90° latching position.

Determining the largest difference between two refractive indexes, evaluated on a large number of identical specimens, for example, leads to the principle refractive indexes and thus to the double refraction that is specific to the substance (see also Section 3.1.3 (5)).

The hardware prerequisites correspond to those detailed in Section 3.1.2 (1).

Note Using BECKE's line and normal bright field lighting, the verification limit of 0.01 in relation to adaptation of the object's and embedding medium's refractive indexes is possible; when using phase contrast (accessory 8.1 ff.), a verification limit of 0.001 is possible.

3.1.3 Determinations with crossed polarisers

(1) Recognising anisotropic specimens (in the orthoscopic beam path)

One manifestation of **optical anisotropy** with transparent specimens is that, when they are illuminated with linear polarised light, almost in each beam direction two light components propagate in the specimen at different propagation rates and two refractive indexes (e.g. $n_{\gamma'}$ and $n_{\alpha'}$) can be assigned to them.
The difference between the light refraction values, the **double refraction Δ n'** has a different value in each beam direction.

The so-called path difference Γ takes into account the irradiated specimen thickness d according to the relation $\mathbf{\Gamma = (\Delta n' \times d)}$.

The path difference ultimately describes the path difference of the light components, which is made visible with the polarisation microscope (and is also measurable).

The largest path difference value can be determined, e.g. evaluated on a large number of similar specimens, or by tilting the specimen in space using a universal rotary stage UD 124, leads to the **double refraction specific to the substance Δ n**, provided the specimen thickness **is known**.

Double refraction in the specimen is recognised by virtue of the fact that when the polariser and analyser are crossed, the field of vision is otherwise darkened, but the specimen point is brightened four times when rotating the specimen stage by 360°. When using white light for illumination, this phenomenon ranges from just visible grey (e.g. on biological specimens) through white and vigorous to weak interference colours (see MICHEL-LEVY colour chart in the annex) to white again, the so-called "higher-order white".

Proceed as follows for the assessment:

- Prepare the microscope as described in Sections 2.6.1 (1) to (3) and 2.6.2 (1) to (3). Position the specimen to be analysed in the middle of the field of vision (over the reticule, if available).

- Swivel in the polariser (3-2/5) and push in the analyser push rod (3-2/2) or the analyser slide ((3-2/1) – equipment 0.1 only –).

- Restrict the illumination aperture on the aperture setting control (3-2/4) to a value around 0.2.

- Rotate the rotary stage Pol (3-2/3) and observe the specimen.

The following conclusions are possible if the specimen always remains dark with the polars crossed and after rotating the stage:

- The specimen is optically isotropic (or, in the case of crystalline material, it belongs to the **cubic** crystal system and then mostly gives itself away by its morphology or divisibility).

- Although the specimen is optically anisotropic, it is in such an intersecting position that one optical axis lies parallel with the beam direction. In this position, no double refraction occurs and the specimen acts as if it were isotropic. This can be resolved by checking the specimen in the conoscopic beam path (see Section (5)).

- The observed point is opaque or is a hole in the thin grind. This can be confirmed by checking the specimen in the bright field.

(2) Determining the extinction inclination

The location of the oscillation direction in the specimen in relation to morphological specimen details such as crystal surfaces, gap directions, twin formations or machining directions on artificial products is an easily definable indication for characterising specimens, e.g. for distinguishing mixed crystals.

Precise marking of the oscillation direction of the crossed polarisers by the eyepiece reticule is a prerequisite for this.
This orientation aid is always provided by the **tubes Pol** (equipment 0.2 to 0.5) automatically as long as Section 2.4 (2) has been observed.

Important In the case of equipment 0.1, a reticule can be oriented by way of the adjustment specimen (accessory 453679) (see Section 2.4 (3))!

Further settings on the microscope are:

- Prepare the microscope as described in Sections 2.6.1 and 2.6.2 (1) to (3) and pay attention to exact lens centring!
- Pull out the analyser push rod (3-2/2) or, for equipment 0.1, the analyser slide (3-2/1).
- Position a distinct contour of the specimen (e.g. a gap or a crystal edge) precisely in the middle of the reticule and turn the stage until the contour (e.g. a gap or crystal edge) is exactly parallel with the horizontal part of the reticule, for example.
- If necessary, optimally adapt the illumination aperture (limit to approx. 0.3 – control (3-2/4) –) and the specimen lighting (bright, but without dazzle) to the specimen's situation; you should preferably use a grey filter (3-2/9).
- Read and take a note of the angle value indicated by the stage index position and the vernier scale on the rotary stage Pol.
- Push in the analyser (3-2/2) or, for the equipment 0.1, the analyser slide (3-2/1).
- Turn the rotary stage Pol (3-2/3) until the specimen is completely darkened at the **next** extinction position.
- Read the angle value by way of the stage index position and the vernier scale on the rotary stage Pol and calculate the difference.

The angle difference describes the extinction inclination and distinguishes objects of even extinction (in the above-mentioned operation = 90°).

(3) Determining the oscillation direction n $_{\gamma'}$ of the specimen

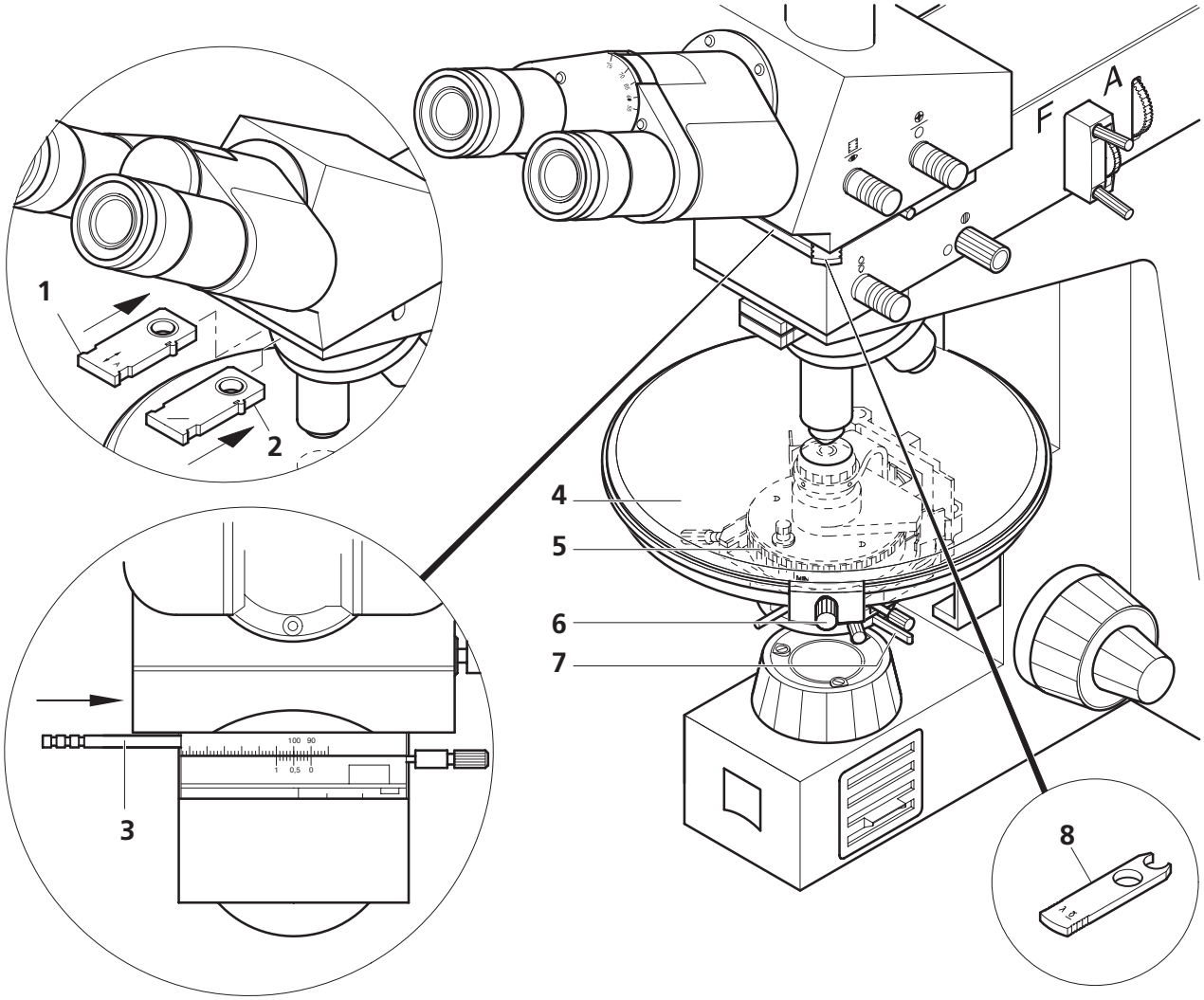


Figure 3-3 Working with compensators

The locations of the two directions with a higher (n $_{\gamma'}$) or lower (n $_{\alpha'}$) refractive index on an anisotropic specimen in relation to morphological directions (crystal surfaces, longitudinal fibre direction etc.) is an important distinguishing feature and is determined as follows:

- Prepare the microscope as described in Sections 2.6.1 (1) to (3) and 2.6.2 (1) to (3). By means of the reticule (if available), position the specimen to be analysed in the middle.
- Swivel in the polariser (3-3/7) and push in the analyser push rod (3-3/3) or the analyser slide ((3-3/1) – equipment 0.1 –).
- By means of the control (3-3/5), limit the aperture to a value of around 0.2.
- Turn the rotary stage Pol (3-3/4) until the specimen is in the extinction position, i.e. it appears **completely dark**, and set the 45° latch (3-3/6) here.

- Turn the stage to the **next** latching position; the specimen is now in the diagonal position and is at its brightest here, e.g. in grey-white (see also Figure 3-4/Ⓐ).

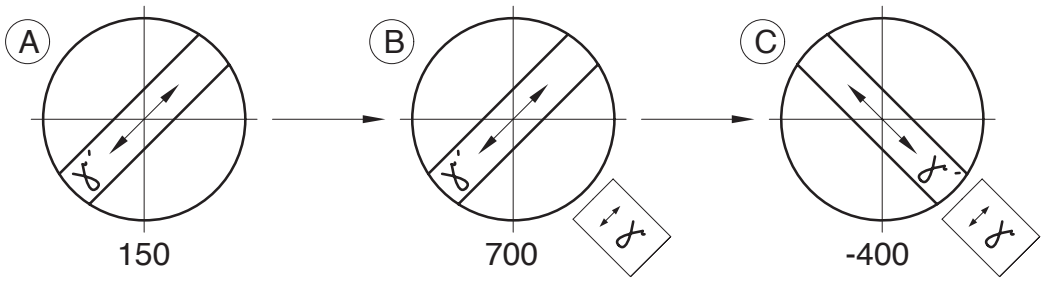


Figure 3-4 Determining the oscillation direction n $_{\gamma'}$ with reference to a synthetic fibre

By referring to the MICHEL-LEVY colour chart in the annex, a path difference of around **150 nm** can be assigned to this "colour" impression (left side: first order / grey blue).

The specimen colour changes to a green blue after sliding in the compensator λ (473704) or, when using equipment 0.1, (453687) (3-3/8 or 2) into the corresponding compensator slot, for example at **700 nm** on the MICHEL-LEVY colour chart (see also Figure 3-4/Ⓑ).

A colour change to yellow-orange, for example at **400 nm** on the colour chart, is observed after rotating the specimen stage by 90° (latch 2x = 90° – this is the second diagonal position of the specimen –) (see also Figure 3-4/Ⓒ).

The following conclusion can be drawn:

- The compensator λ produces a fixed path difference of approx. 550 nm.
- The orientation of n $_{\gamma}$ (see marking on the compensator shaft) is fixed in the NE-SW direction.
- The "higher" interference colour on the specimen (at 700 nm, Figure 3-4 /Ⓒ) can only have come into being by addition of the specimen's and compensator's path differences (approx. 150 + 550 = approx. 700 nm), while the "lower" interference colour (approx. 400 nm, Figure 3-4/Ⓒ) can only have been produced by subtraction (approx. 150 - 550 = -400 nm). In doing so, the interference colour of a path difference is independent of the mathematical sign, i.e. –400 nm = 400 nm.
- Addition takes place when $n_{\gamma'}$ of the compensator and $n_{\gamma'}$ of the specimen are parallel; consequently, n $_{\gamma'}$ of the specimen also lies in the NE-SW direction in a higher interference colour. In the chosen example, this co-insides with the fibre's longitudinal direction and is described here as being optically positive (see also Figure 3-4/Ⓑ).

The higher path difference / the higher interference colour comes into being when the n $_{\gamma'}$ direction of the specimen and compensator are parallel. When the $n_{\gamma'}$ direction of the compensator is specified, the $n_{\gamma'}$ direction of the specimen is also defined.

Note An analogous consideration applies when using a compensator λ/4, in which case this compensator produces a fixed path difference of approx. 135 nm.

(4) Determining the path difference with reference to the MICHEL-LEVY colour chart

The interference colour of a specimen in the diagonal position, compared with the colour/path difference order of the MICHEL-LEVY colour chart, results in only a rough path difference statement with an accuracy of around ± 10 ... 20 nm.

For unpractised users, assigning specific interference colours of the specimen to the first, second or third order is slightly problematical.

The schematic in Figure 3-5 shows an example of how to clearly **differentiate** the colour "indigo" of the second or third order. Besides the interference colour of the specimen, the colour change in the addition (+) and subtraction depiction (–) when adding a compensator λ (473704, for equipment 01 – 453687) or λ/4 is used for assessment.

In doing so, the settings on the microscope and on the specimen are identical to the settings in Section 3.1.3 (3).

The colour change is assessed in **both** diagonal positions of the specimen (by latching 2x on the stage).

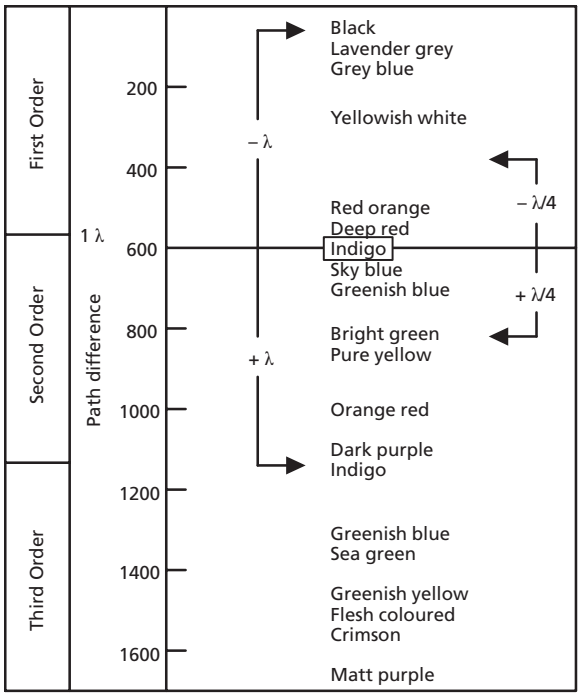


Figure 3-5 Schematic depiction of the colour chart for the addition and subtraction positions

Question:
Is the object colour the "indigo" of the second order (600 nm) or of the third order at 1,150 nm?

Colour change when adding a compensator λ or λ/4 in both diagonal positions of the specimen:

Addition		Subtraction	
λ	λ/4	λ	λ/4
Indigo 3	Greenish blue 2	Lavender grey 1	Red orange 1

The colour transition, e.g. from "Indigo" to "Grey black" in the subtraction position of the specimen and compensator λ is achieved only for the interference colour **"Indigo" of the second order.**

NOTE If the thickness d of the specimen is known or measurable, the colour chart can be used to determine the double refraction Δ n' in the respective intersecting position by tracing the guide beam, starting from the intersecting point for the Γ-value and the known thickness d in the downward direction or to the outside right up to the edge of the table.

NOTE MICHEL-LEVY colour charts are optainable under order no. 42-312.

(5) Measuring path differences (equipment 0.2 to 0.5 only)

Measuring compensators (accessories 3.6 to 3.10) are needed to precisely measure path differences. They lead back to zero (black of the first order), i.e. they compensate the path difference generated by the specimen.
While the addition position or even the subtraction position was relevant in the methods described above, when carrying out measurement **only** the subtraction position is of interest.

Path differences in the specimen may assume very low values (1/50 λ or 10 nm) and very high values (50 ... 100 λ) ≙ approx. 27000 ... 60000 nm and thus determine the compensator suitable for measurement.

The suitable compensator is determined as follows:

- Prepare the microscope as described in Sections 2.6.1 (1) to (3) and 2.6.2 (1) to (3). Exactly position the specimen to be analysed over the middle of the reticule.

- Limit the aperture to a value around 0.2 by means of the control (3-3/5).

- Turn the rotary stage Pol (3-3/4) until the specimen is in the extinction position, i.e. it appears **completely dark**, and set the 45° latch (3-3/6) here.

- Latch the specimen stage **once** (by 45°) so that the specimen is in the diagonal position (brightened).

The interference intensity or colour produced by the specimen allows us to arrive at the following conclusion:

* If more or less vigorous interference colours appear on the specimen, the path difference is approx. between 1/2 λ and approx. 5 λ.

  The suitable compensator is:
  EHRINGHAUS 0 to 6 λ (accessory 453720).

* If introduction of a compensator λ (473704 or 453687) (3-3/8 or 4) in the compensator slot results in a change in the colour of the specimen from light grey/white to a vigorous interference colour, the path difference is ($^1/_4$ ... $^1/_2$) λ.

  NOTE In certain circumstances, evaluation in two specimen positions rotated by 90° is a prerequisite for the occurrence of the colour changeover effect; to do this, rotate the centred specimen stage (2 latching positions).

  The suitable compensator is:
  EHRINGHAUS 0 to 6 λ (accessory 453720) or the compensation method according to DE SENARMONT; up to 1 λ, using the SENARMONT compensator (accessories 473718 and 260201 – 5600.426).

* After inserting the compensator λ and rotating the specimen by 90° – latching 2x – the white remains as the interference colour, but it is a "higher-order" white and therefore the path difference is more than > 6 λ.

  The suitable compensator is:
  EHRINGHAUS 0 to 130 λ (Accessory 453722).

* Very slight path differences (≦ 1/8 λ or 65 nm) can be concluded if the interference intensity is a dark grey.

  The suitable compensator is:
  BRACE-KÖHLER 1/8 λ (Accessory 453721).

- Insert the compensator in the slit (3-3/8) until it bottoms.

  Important Tilting compensators must only be inserted or removed in the 90° position – see scale on gearbox!

  Refer to the following operating instructions for details of how to prepare and carry out measurements:

For tilting compensators 0 ... 6 λ	30 - G 534
For tilting compensators 0 ... 130 λ	30 - G 533
For measurements according to DE SENARMONT	G 41 - 510
For measurements according to BRACE–KÖHLER	G 41 - 516

  NOTE To achieve exact measurement and to determine the dispersion of double refraction, you must work with monochromatic light; to do this, use an SB filter (accessories 7.9 and 7.10, Section 1.4 (2)).

  NOTE See Page 4 of the above-mentioned instructions for details of how to adjust the SENARMONT compensator.
  Carry out measurement analogously to Page 5, align the $n_{\gamma'}$ - direction of the specimen in parallel with the compensator slit (for determination, see Section 3.1.3 (3), Figure 3-4/Ⓒ).
  The analyser is rotated only in the mathematically positive sense.
  Insert the angle difference $\Delta u = (u - 90°)$ for path difference calculation into the formula on Page 7.

  NOTE For calculation according to BRACE-KÖHLER, use the compensator constant Γ_o specified on the accompanying slip.
  Adjust the compensator analogously to Item 2 of the above-mentioned instructions. This compensator **only** has a vernier scale; its zero position u_o is at approximately 90°.
  Determine the angle difference $\Delta u = (u - u_o)$ by means of the measuring drum and the course scale on the gearbox and insert it in the formula in Item 2 of the above-mentioned instructions.

(6) Recognising anisotropic specimens in the conoscopic beam path

A decision a to whether optical isotropy or anisotropy is encountered, which is not always clear in the orthoscopic beam path, can mostly be improved by means of the conoscopic beam path. Furthermore, the conoscopic image provides new possibilities of differentiating crystalline specimens.

When the focal plane of the lens is viewed with the BETRAND lens, **amorphous isotropic** material (e.g. glasses) or crystalline substances belonging to the **cubic** crystal system **do not exhibit any** change in the extinction figure (wide, dark cross).

Even the **slightest double stress refractions** can be verified sensitively by a more or less clear "opening" of the extinction figure.

Under orthoscopic observation, **specific intersecting layers of anisotropic materials** do not result in any periodic brightening when the stage is rotated. Under conoscopic observation, however, **uniquely identifiable interference phenomena in the focal plane of the lens**, the so-called axis images, are manifest.

Almost any intersecting layer on anisotropic crystalline materials allows a decision between **single-axis or two-axis** (see Section 3.1.3 (7)), with the exception of the main sections of optically single-axis specimens and the sections of two-axis specimens that are optically parallel to the axis plane. Here, a path difference measurement (see Section 3.1.3 (5)) is appropriate in the orthoscopic beam path.

Therefore, anisotropic specimens which, when observed orthoscopically, do not brighten much on rotation of the stage and have been selected out of a large number of similar specimens are particularly suitable for conoscopy.

The microscope settings for conoscopic observation are described in Section 2.6.2 (4) and are presumed here.

The following are important for setting:

* The use of suitable high-aperture lenses,
* exact centring of these lenses,
* exact setting of the luminous field diaphragm via the condenser drive,
* a high illumination aperture by completely opening the aperture diaphragm,
* when using the condenser 0.9 Z pole, additionally opening the luminous field diaphragm,
* activation of the BERTRAND lens via the push rod,
* full luminous intensity by controlling the lamp to 6 V.

(7) Defining the optical character of anisotropic specimens on a conoscopic image

Crystalline anisotropic specimens can be separated into optically single-axis and two-axis specimens, each with an "optically positive" or "negative" character.

In most cases, **single-axis** specimens show a **narrow black cross** in parallel with the oscillation directions of the polarisers and, depending on the amount of double refraction and the thickness of the specimen, **concentrically arranged coloured interference rings (the so-called isochromates)** (see also Figure 3-6, second row).

This cross remains closed when the stage is rotated and, depending on the intersecting location, lies inside or outside of the imaged lens pupil.

In the case of **optically two-axis** crystals, the cross dissolves into two **dark hyperbole branches (the so-called isogyrs)**, depending on the **amount of rotation of the stage** which, depending on the amount of double refraction and the thickness of the specimen, are surrounded by coloured interference figures (reminiscent of the number "8").

Presuming a starting position of the axis image as shown in Figure 3-6, the schematically shown coloured changes (blue or yellow areas) are produced on the axis image when a compensator λ (473704) or λ/4 (473714) or a wedge compensator 0 - 3 λ (473724) is inserted in the compensator slit (3-3/8 or 2), thus allowing differentiation between "optically positive" and "negative".

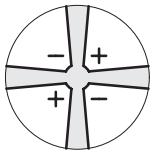
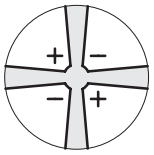
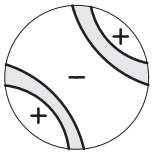
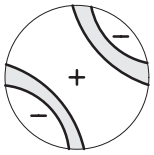
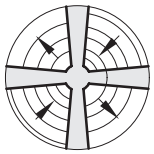
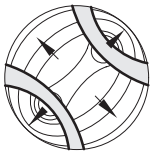
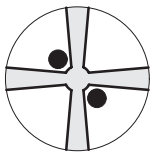
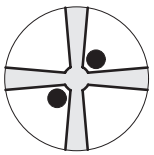
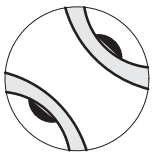
	Optically 1-axis		Optically 2-axis		
	Positive	Negative	Positive	Negative	
λ plate (white → blue → yellow)					+ ≙ blue – ≙ yellow
Quartz wedge (direction of movement when inserting)					Direction of movement
λ/4 plate (locations of the black spots)					

Figure 3-6 Determining the optical character

If the intersections are less favourable, i.e. the centre of the cross of optically single-axis specimens or the isogyrs of optically two-axis specimens is outside of the lens pupil, assessment is possible as follows:

- If the black isogyrs are **rectilinear** and if they run in parallel through the pupil (in relation to the reticule), the specimen is an **optically single-axis specimen**.

- If the black isogyrs are **curved lines** that migrate through the pupil on a circular path, the specimen is an **optically two-axis specimen**.

Such axis images (not shown in the schematic 3-6) can also be interpreted if the appropriate attention is devoted to them.

NOTE Axis images can often be presented better with circular polarisation (Accessory 2.8). Particularly determination of the axis angle of optically two-axis specimens (practically the distance between the isogyrs) is much clearer.
The optical character can also be determined.
To do this, use the compensator λ, 6 x 25 (Accessory 453704), placed in the compensator slit (3-3/2).

3.1.4 Objective determination methods

(1) Transmitted light photometry

For objective determination, e.g. of transmission on a wide diversity of substances, (simple) transmitted light photometry is a particularly suitable instrument. The attachment photometer MPM 100 (Accessory 457325), adapted to the Axiolab Pol (Section 2.8.3) optimally fulfils these requirements.

(2) Spectral photometry

The diode line spectrometer system is suitable for determining spectral absorption bands on complex compounds, for instance.

3.2 Reflected light applications

The reflection capacity, colour and structural characteristics are important diagnostic characteristics of opaque materials. Combined with further attributes such as determination of micro-hardness or characteristic anisotropy properties, many substances are described to an adequate extent.

3.2.1 Observation without polarisers (reflected light bright field)

The impression of different brightness or colour nuances on opaque specimens is based on the interaction between the light used for lighting and the wavelength-dependent absorption properties of the material's surface. Differing brightness and colour impressions in the specimen are either (characteristically) specific to the material or, in the case of anisotropic specimens, are also a manifestation of differing specimen orientations.

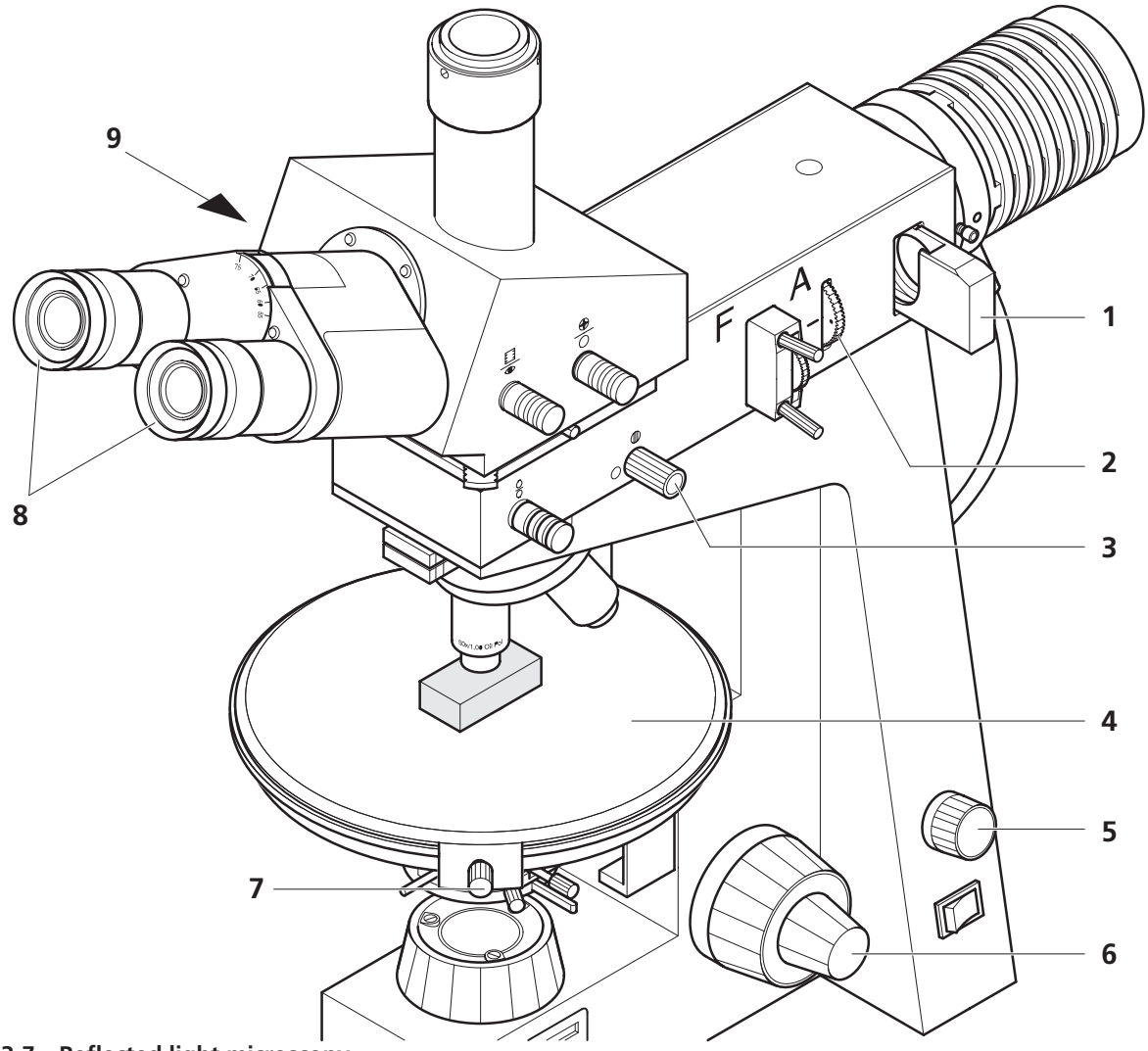


Figure 3-7 Reflected light microscopy

- Prepare the microscope as described in Section 2.6.3 (1) to (3).
- Switch off polarisers (3-7/3) (marking on the "◯" symbol) and, if necessary, reduce the lighting aperture (3-7/2).
- Optimally adjust lighting of the specimen (bright, but without dazzling); to do this, use a neutral and grey filter, using a conversion filter for colour assessment (3-7/1).
- Lower the room brightness and use eye cups to avoid side light.
- The use of immersion lenses (accessories 442443 and 442453) is additionally recommended to differentiate slight reflection differences and, in the case of low-reflection specimens, to enhance contrast.

NOTE On structures of differing hardness, a light line (SCHNEIDERHÖHN line) analogous to BECKE's line in transmitted light, can be recognised at the grain limits. When the **distance between the specimen and lens is enlarged** by moving the fine drive (3-7/6), this light line moves **towards the softer medium**.

3.2.2 Determination with the polariser (bireflection)

Bireflection describes the property of directionally dependent absorption and dispersion of reflected light on optically anisotropic opaque substances. When using linear polarised light for illumination, bireflection is recognisable by a more or less clear brightness and/or colour change of the specimen when the rotary stage Pol (3-7/4) is rotated.
Extreme discrepancies in reflection capacity, i.e. non-radial discrepancies, each exist after rotating the stage by 90° (use the latch (3-7/7) - 2x) and can also be determined quantitatively in these specimen positions (see Section 3.2.4 (1)).

Exact adjustment of the dark position between the crossed polars as the starting azimuth (see Section 3.2.3) and then setting the 45° latch (3-7/7) is useful for finding these distinct azimuths of the specimen..

In doing so, the lighting conditions must be adapted even better to the conditions of the specimen. This anisotropy effect can be depicted substantially more clearly when using immersion lenses (accessories 442443 and 442453).

3.2.3 Determination with crossed polarisers

Optical anisotropy between crossed polars is the result of dispersion of the light or an interaction of the differences between the light refraction index (double refraction) and absorption coefficients effective on the material of the surface, which cause a change in the polarisation condition that is dependent on the direction (and on intersection). Analogously to anisotropic specimens viewed in transmitted light, a fourfold change from the bright position (diagonal position) and the dark position (normal position) occurs each time the specimen stage is rotated by 45°.

Between crossed polars, isotropic absorbing media appear dark in every azimuth, i.e. when the specimen stage is rotated. This is also possible in specific positions of intersection with the crystallographic structure of anisotropic specimens.

These anisotropy effects (brightening and colour changes) are generally very low-light phenomena. The brightness in comparison with observation without polars is only 0.1 - 2 %!

Owing to this fact, the following working conditions are recommended:

- Prepare the microscope as described in Section 2.6.3 (1) to (3).
- Exactly crossed position of the polarisers (activate polariser 3-7/3 – pay attention to the marking with respect to the symbol "⊜" – and to precise adjustment of the analyser (3-7/9) (exactly 90°).)
- Reduce the illumination aperture to 0.15 ... 0.20 (3-7/2).
- Illuminate the specimen with maximum lamp output (3-7/5).
- Slide the attenuation filter out of the beam path (3-7/1).
- Reduce room brightness and use eye cups (3-7/8) to avoid side light.
- Allow your eye to adapt to the darkness for an adequate length of time.
- The anisotropy effects can be shown clearly when using immersion lenses (see Accessories 5.14 to 5.17), but frequently result in different colour impressions, which can also be evaluated diagnostically.

You should not forget to activate the attenuation filter 0.06 in the filter slide (3-7/1) when changing to observation with crossed polars for bright field observation.

3.2.4 Objective determination methods

(1) Reflected light photometry

Determining the reflection capacity or the uniradial reflections of anisotropic specimens is one of the most important methods of reflected light polarisation microscopy. Here, a qualitative statement is already sufficient, but can often not be substituted by an objective quantitative analysis. The attachment photometer MPM 100 (Accessory 457325) described in Section 2.8.3 is an easy-to-handle possibility of doing this.

(2) Spectral photometry

Spectral photometry is also increasingly gaining in significance as a modern instrument of colorimetric analysis of intrinsic colour or of the interference colours of anisotropic specimens.

Here, ZEISS offers extensive possibilities by adapting the spectral photometer MPM 200 and the diode line spectrometer to this unit.

(3) Micro hardness testing

Besides photometry, micro hardness testing is the second "pillar" of objectively determining the characteristics of opaque specimens. Ore minerals can be identified uniquely by determining their reflection capacity and micro hardness.
The BOWIE-TAYLOR diagram and the affiliated tables are helpful here.

The MHP 10 from Messrs. PAAR can be adapted to the Axiolab Pol for determining micro hardness (please enquire).

4 Care and troubleshooting

4.1 Care

Care of the Axiolab Pol microscope is limited to the following operations:

- Cover the unit with the dust cover after every use. This is particularly important because soiling from particles (e.g. dust) on the polarisation microscope may result in clear contrast reduction.
- Do not place the unit in a humid room.
- Remove dust from optical surfaces with a rubber blower or with a natural hair brush. Degrease the brush in alcohol and then dry it.
- Use commercially available optical and spectacle cleaning cloths to remove extreme soiling (e.g. fingerprints), but do not apply excessive pressure, which would stress or scratch the optical systems. If necessary, moisten cloths lightly with petroleum ether. If necessary, clean the front surfaces of lenses with light petroleum, but do not use any alcohol.

When using the Axiolab Pol in moist and warm climate zones, pay attention to the following notes:

- Store the Axiolab Pol microscope in bright, dry and well-ventilated rooms with a humidity less than 75 %; store particularly sensitive modules and accessories such as lens and eyepieces in their capsules or in dry cabinets.
- When storing the microscope or its parts in closed receptacles for prolonged periods of time, fungi can largely be avoided by placing absorbent substances soaked in fungicide in the receptacles.

IMPORTANT Fine mechanical and optical devices are always at a risk of fungus infection under the following conditions:

- Relative humidity > 75 % for more than three days at temperatures from +15 °C to +35 °C,
- Placing them in dark rooms where there is no movement of air and
- In the event of dust deposits and fingerprints on optical surfaces.

4.2 Troubleshooting and servicing

Troubleshooting on the Axiolab Pol microscope is limited to only a few activities:

- Check the mains power supply
- Check the lighting unit
  - Replace fuses as described in Section (1)
  - Replace the halogen lamp on the transmitted light unit as described in Section (2)
  - Replace the halogen lamp on the reflected light unit as described in Section (3)
  - Replace the HAL 12 V 100 W lamp as described in Section (4)

(1) Checking the mains supply

- Check the mains cable (4-1/4) and replace it if necessary.
- Remove the fuse holder (4-1/1) by simultaneously pressing in the direction indicated by the arrows and check the G-fuse links (5 x 20 mm) (4-1/3) conforming to IEC 127:
  - For 230 V: 0.4 A / 250 V slow-blow
  - For 115 V: 0.8 A / 250 V slow-blow
- Replace defective fuse links.
- Check whether the fuse socket (4-1/2) is inserted correctly for the available mains voltage. If necessary, insert the socket correctly. The set voltage value can be seen from the outside through a sight glass in the fuse holder.

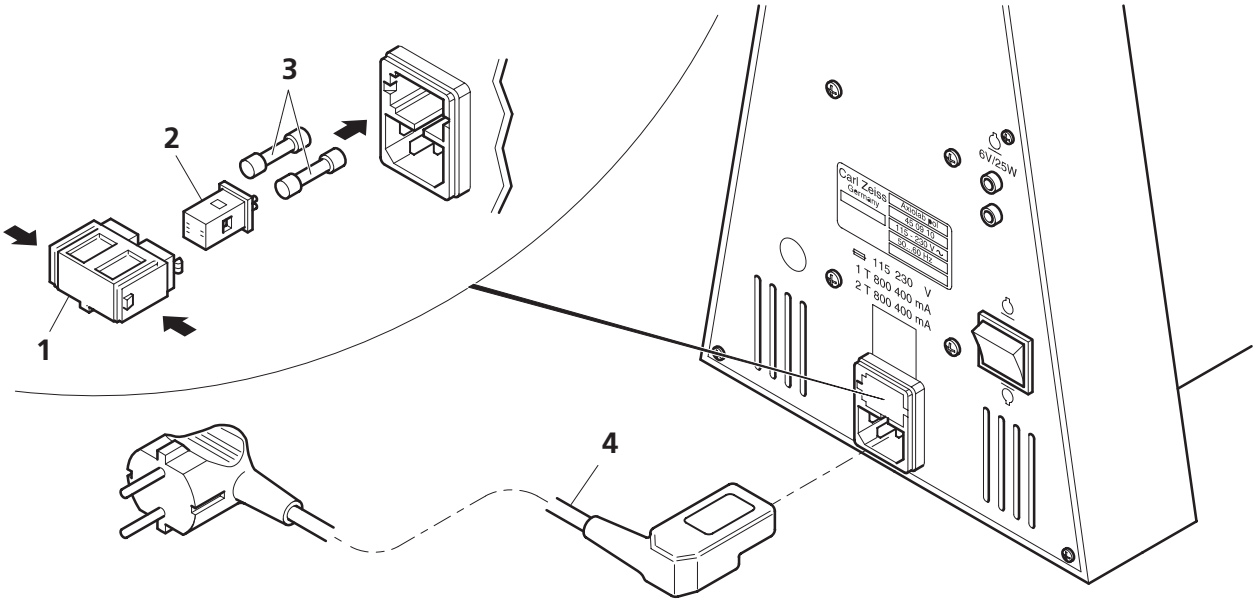


Figure 4-1 Checking the mains supply

(2) Replacing the lamp on the transmitted light unit (HAL S 5 A 6 V 25 W)

Proceed as follows when replacing the lamp of the built-in transmitted light unit:

- Switch off the lamp's power supply with the on/off switch (4-2/1); allow the lamp to cool down.
- Disconnect the mains cable from the mains.
- Grip the ventilation grille (4-2/2) by the handle and extract it in the upward direction.
- Pull out the lamp module by the handle element (4-2/3), pressing the handle element together to do this.
- Grip the halogen lamp (4-2/4) by the holder part at the sides and extract it from the guide rails.
- Remove a new 6 V 25 W halogen lamp from the packaging box and slide it onto the guide rails as shown in Figure 4-2. Pay attention to an exact fit of the lamp carrier plate on the positioning and fixing pins.

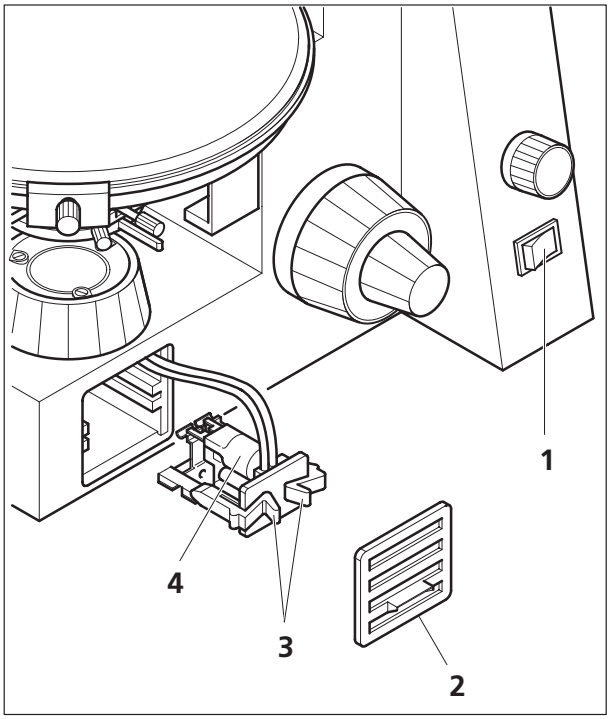


Figure 4-2 Lamp replacement (transmitted light)

- Reinsert the lamp module; to do this, press the handle element together slightly.
- Fit and engage the ventilation grille.

IMPORTANT Do not touch the bulb of the lamp with your bare hands; if necessary, clean the bulb with pure alcohol before switching on for the first time to thus avoid burning in of soiling.

(3) Replacing the lamp on the reflected light unit (HAL S 5 A 6 V 25 W)

Proceed as follows when replacing the lamp on the reflected light unit:

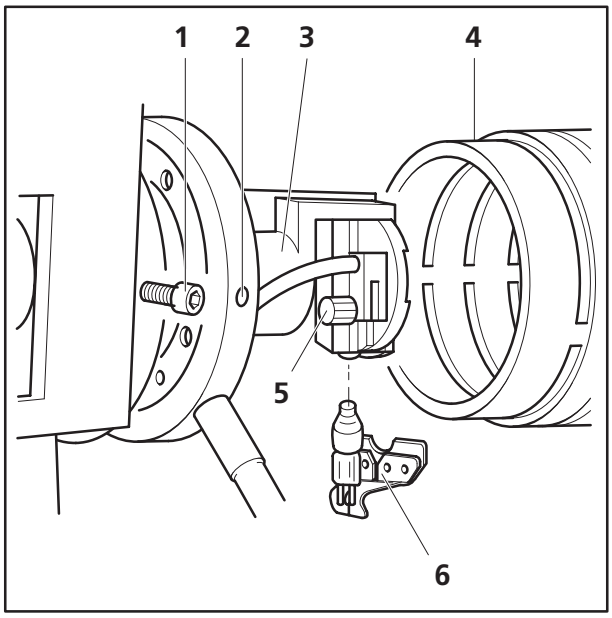


Figure 4-3 Lamp replacement (reflected light)

- Switch off the lamp's power supply with on/off switch; allow the lamp to cool down.
- Disconnect the mains cable from the mains.
- Pull the connecting cable of the lamp out of the connection socket.
- Turn the cover hood (4-3/4) to the left and extract it towards the rear.
- To facilitate lamp replacement, detach the holder part (4-3/3) from the intermediate tube A/HF; to do this, undo the hexagon screw (4-3/1) by a few turns.
- Undo both securing screws (4-3/5) by turning them to the left and take out the carrier plate (4-3/6) including the lamp.
- Take a new 6 V 25 W halogen lamp out of its box and insert it in the holder part (4-3/3); in doing so, one tip of the ceramic base must engage in the centring notch of the carrier plate and the carrier plate must sit well on the second tip.
- Firmly tighten the securing screws (4-3/5) by turning them to the right.

IMPORTANT Do not touch the bulb of the lamp with your bare hands; if necessary, clean the bulb with pure alcohol before switching on for the first time to thus avoid burning in of soiling.

- Again fit the lamp on the intermediate tube. Position the lamp so that the black orientation dot (4-3/2) is at the same level as the screw (4-3/1). Tighten the hexagon screw (4-3/1) again.
- Fit the cover hood (4-3/4) and lock it by turning it to the right.
- Connect the lamp's connecting cable on the stand.

(4) Replacing the lamp on the lighting unit HAL (HAL 12 V 100 W)

Carry out the following activities when replacing the lamp of the lighting unit HAL:

- Switch off the lamp by means of the on/off switch on the power supply.
- Disconnect the mains cable from the mains.
- Undo the hexagon screw (4-4/3) and extract the lamp housing (4-4/4) in the upward direction.
- Press on the two spring levers (4-4/5) in the direction indicated by the arrows and replace the defective lamp HAL 12 V 100 W (4-4/2).

NOTE When inserting the new lamp, make sure that you do not remove the paper cover (4-4/1) until you have inserted the lamp.

- After replacing the lamp, fit and secure the lamp housing again.
- If necessary, centre the lighting unit in accordance with the criteria of an illuminated image field.

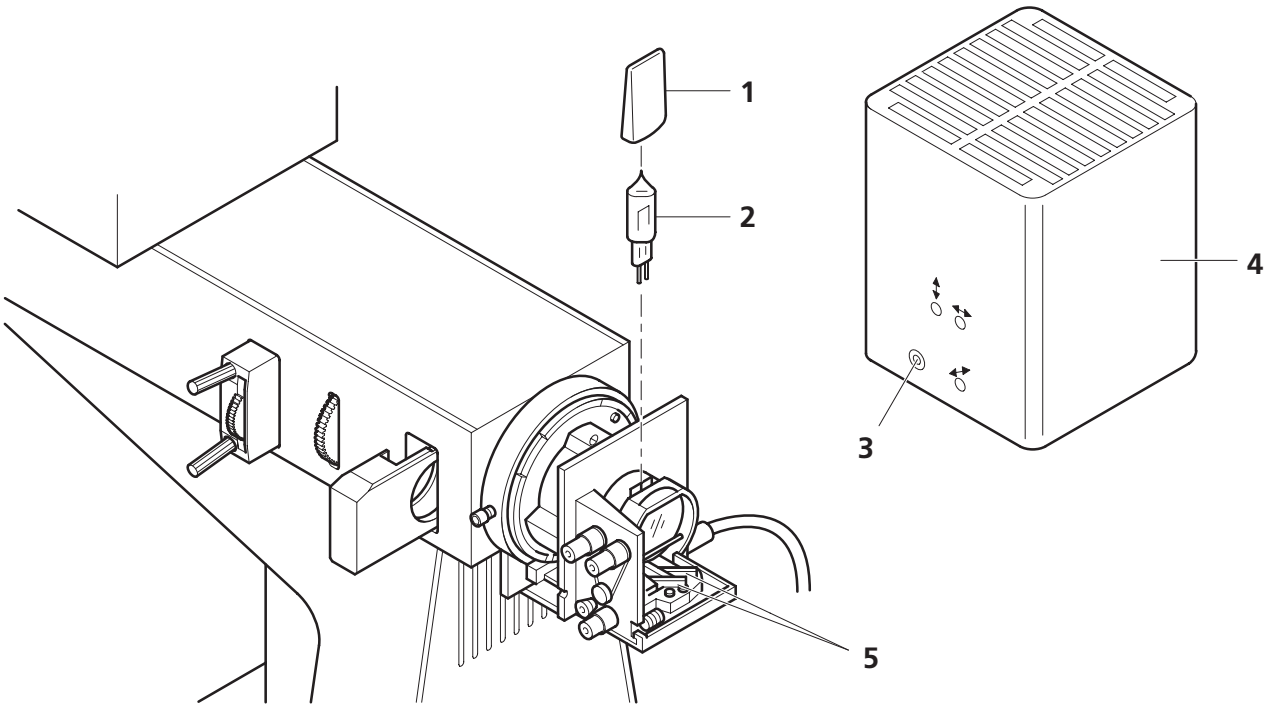


Figure 4-4 Replacing the lamp on the lighting unit HAL

(5) Service

All tampering on optical parts or motion elements in the interior of the unit or work on the electrics of the Axiolab Pol may only be carried out by service specialists or specially authorised personnel.

For servicing, contact your nearest regional representative or

Carl Zeiss Jena GmbH
Zeiss Gruppe
Unternehmensbereich Mikroskopie
Tatzendpromenade
D-07745 Jena

Phone: (03641) 64-2936
Fax: (03641) 64-3144

APPENDIX

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- List of abbreviations
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List of abbreviations

A	Aperture diaphragm
a/f	Opening (across flats)
AL, A	Reflected light
achr.	Achromatic
apl.	Aplanatic
ASTM	American Society of Testing Materials
B	Blue glass
BP	Bandpass
C, C-Mount	Camera thread
CB	Conversion blue (daylight filter)
CE	Communautés Européennes (European Communitiy)
CISPR	Comité International Spécial de Perturbation Radioélectrique
CSA	Canadian Standards Association
CP	Clinical Plan (CP-Achromat)
d	Specimen thickness
D	Diameter or cover glass thickness
DC	Direct current
DL, D	Transmitted light
DF	Dark field
DIC	Differential Interference Contrast
DIN	German Industrial Standard
EG	European Community
EMVG	German law governing the electromagnetic compatibility of devices
EN	European standard
ENG	Electronic News Gathering (bayonet coupling point of CCD cameras)
Epi	Specially for reflected light
EPL	Epiplan
E-Pl	Plane eyepieces with aspherical corrected optics
EWG	Europäische Wirtschaftsgemeinschaft (European Economic Community)
F	Field diaphragm, also luminous field diaphragm
Fl	Fluorescence
foc.	Focusing
FWD	Free Working Distance
Γ	Polarisation-optic path difference
HAL	Halogen lamp
HBO	Mercury vapour short arc lamp
HF	Bright field

ICS	Inifinity Colour-corrected System
IEC	International Electrotechnical Commission
IF	Interference Filter
IP	International Protection
ISO	International Organization for Standardization
λ	Wavelength of light
LD	Long Distance
LED	Light Emitting Diode
LP	Long pass
man.	Manual
MC	Microscope camera
MHP	Micro-hardness tester
Mot., mot.	Motor-driven
MPM	Mikroskop photometer
N = 0,6	Neutral filter with a transmission of 0.06 (≙ 6 %)
$n_{\gamma'}$	Refractive index of the slow wave
P	Photometry
Pl	Plane
POL, Pol	Polarisation
Ph	Phase contrast
SB	Narrowband filter
SK	Class of protection
SLR	Single lens reflex
spec.	Spectacle wearer
S-Pl	Super-plane (for photo eyepieces)
TÜV	Technischer Überwachungsverein (German technical inspectorate)
TV	Television
UD	Universal rotary stage
UL	Underwriters Laboratories
vis.	Visual
XBO	Xenon short arc lamp
Z	Centring
ZN	ZEISS standard

References

Beyer, H. und Riesenberg H. (Herausgeber): Handbuch der Mikroskopie
Verlag Technik, Berlin 1988

Burri C.: Das Polarisationsmikroskop
Birkhäuser Verlag, Basel 1950

Burri C.: Zur Theorie und Praxis der Drehkompensatoren nach BEREK und EHRINGHAUS
Z. Angew. Phys. 4, 418 – 426, 1953

El-Hinnawi: Methods in Chemical and Mineral Microscopy
Elsevier Publishing Company, Amsterdam-London-New York 1966

Emons, H. H., Keune, H. und Seyfarth, H. H.: Chemische Mikroskopie
Deutscher Verlag für Grundstoffindustrie, Leipzig 1973

Freund, H. (Herausgeber): Handbuch der Mikroskopie in der Technik – 8 Bände
Umschau Verlag, Frankfurt am Main 1954 ff.

Gahm, J.: Quantitative polarisationsoptische Messungen mit Kompensatoren
ZEISS Mitteilungen 3, 153 – 192, 1964

Galopin, R., und Henry, N.F.M.: Microscopy study of opaque minerals
Heffer and sons, Ltd., Cambridge 1972

Heinrich, E. W.: Microscopic idenfication of minerals
MC Graw-Hill, New York 1965

Kordes, E.: Optische Daten zur Bestimmung anorganischer Substanzen mit dem Polarisationsmikroskop
Verlag Chemie, Weinheim 1960

Leeder, O. und Blankenburg, H-J.: Polarisationsmikroskopie
Deutscher Verlag für Grundstoffindustrie, Leipzig 1989

Mosebach, R.: Das Messen optischer Gangunterschiede mit Drehkompensatoren
Heidelberger Beitr. Mineral. u. Petrogr. 1, 515 – 528, 1949

Raaz, F. und Tertsch, H.: Geometrische Kristallografie und Kristalloptik und deren Arbeitsmethoden
Springer-Verlag, 3. Aufl. Wien 1958

Ramdohr, P.: Die Erzminerale und ihre Verwachsungen, 3. Aufl.
Akademie-Verlag, Berlin 1960

Reinhardt, M.: Universaldrehtischmethoden
Verlag von B. Wepf, Basel 1931

Rinne-Berek: Anleitung zur allgemeinen und Polarisationsmikroskopie der Festkörper im Durchlicht
Neu bearbeitet von Schumann, H. und Kornder, F. – 3. Aufl.
E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart 1973

Rittmann, A.: Quantitative Konoskopie
Schweiz. mineral. petrogr. Mitt. 43, 11, 1963

Rösch, S.: Über Interferenzfarben im polarisierten Licht an Substanzen mit Dispersion der Doppelbrechung (Brewster-Herschel-Farben)
Tscherm. Mineral. Petrogr. Mitt. 8, 36 – 48, 1962

Rosenbusch, H. und Wülfing, E. A.: Mikroskopische Physiografie der petrografisch wichtigen Mineralien, Bd. I, 1. Hälfte
Stuttgart 1921/24

Rosenbusch, H. und Mügge, O.: Mikroskopische Physiografie der petrografisch wichtigen Mineralien, Bd. I, 2. Hälfte, Spezieller Teil
Stuttgart 1927

Schumann, H.: Über den Anwendungsbereich der konoskopischen Methodik
Fortsch. Mineral. 25, 217 – 235, 1941

Schumann, H.: Metallografie
Deutscher Verlag für Grundstoffindustrie, Leipzig 1991

Seyfarth, H. H. und Keune, H.: Phasenanalyse fester Rohstoffe und Industrieprodukte
Deutscher Verlag für Grundstoffindustrie, Leipzig 1980

Shelly, D.: Optical Mineralogy – 2. Aufl.
Elsevier, New-York-Amsterdam-Oxford 1985

Shouten, C.: Determination tables for one microscopy
Elsevier Publishing Company Amsterdam-New York 1962

Tröger, W. E. und Braitsch, O.: Optische Bestimmung der gesteinsbildenden Minerale, Teil 2, Textband, 2. Aufl.
E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart 1971

Tröger, W. E.: Tabellen zur optischen Bestimmung der gesteinsbildenden Minerale, 4. Aufl.
E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart 1971

Van Maaren, P. W.: Statische en kinematische microscopie
Elsevier Verlag, Amsterdam-Brüssel 1977

Wahlstrom, E. E.: Optical crystallography
J. Wiley & Sons, New York 1969

Winchell, A. N. und Winchell, H.: Elements of optical mineralogy
J. Wiley & Sons, New York 1951

Winchell, N. W. und Winchell,A.N.: The microscopical characters of artifical inorganic solid substances Optical properties of artifical minerals
Academic Press, New York 1964

Zschach, S.: Zirkularpolarisation im Durchlicht mit den Mikroskopen Axioskop®, Axioplan® und Axiophot®, MICRO INFO, Edition 33, Juni 1993
Carl Zeiss, Geschäftsbereich Mikroskopie, 07745 Jena

Zussmann, J.: Physical Methods in Determinative Mineralogy
Academic Press, London-New York 1967